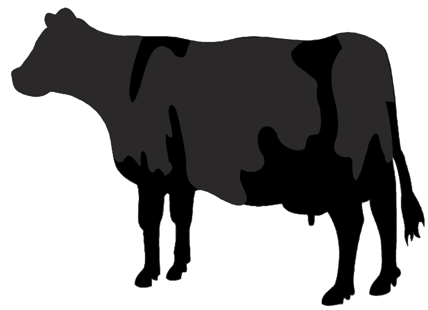

APPENDIX M:

Literature Review:
an Assessment of Beneficial and Adverse Impacts of Livestock Grazing to Fish, Wildlife, Plants, and their Habitat on Stillwater NWR Complex

NEXT HOME

Appendix M

LIVESTOCK ON THE STILLWATER NATIONAL WILDLIFE REFUGE COMPLEX: AN ASSESSMENT OF BENEFITS AND ADVERSE IMPACTS

Prepared by: Don DeLong[1]
Stillwater National Wildlife Refuge
U.S. Fish and Wildlife Service
Fallon, Nevada 89406

March 2000

NEXT   HOME

[1] Current location: National Elk refuge, Jackson, WY.

INTRODUCTION

This report provides an assessment of the positive and negative effects of livestock herbivory on native plant and animal communities in Stillwater National Wildlife Refuge (NWR), Stillwater Wildlife Management Area (WMA), and Fallon NWR, and provides an evaluation of the potential use of livestock toward accomplishing the purposes of Stillwater NWR and Fallon NWR (purposes of Stillwater WMA are not addressed because the designation will cease to exist after November 1998). It is not a comprehensive review of the subject, although I attempted to provide representative examples of differing philosophies on the subject.

U.S. Fish and Wildlife Service (Service) policy directs that livestock grazing, as a management practice, may be permitted on a national wildlife refuge when it enhances, supports, and contributes to established wildlife management objectives (USFWS 1982:6 RM 9.1). It can also be permitted on a refuge if it is determined to be compatible with the purposes for which the refuge was established. A compatible use is defined as one that does not measurably detract from or interfere with achieving the purposes for which the refuge was established, as defined in the National Wildlife Refuge System Administration Act of 1966, as amended. This act requires that a compatibility determination must be completed before any recreational or other use occurs on a national wildlife refuge, and that the determination be based on available scientific information, among other factors. The Service is not required to independently generate any data to assess compatibility of uses. This report represents an assessment of available scientific information pertinent to the effects of livestock grazing on Stillwater and Fallon NWRs, including beneficial effects.

Comments received from the public during the scoping process for the Stillwater NWR Complex comprehensive conservation plan have ranged from the assessment that livestock grazing is needed to provide high-quality wildlife habitat to the argument that livestock should be removed from the refuge because they degrade wildlife habitat. This report explores the various positions and was prepared in an attempt to provide an objective analysis of the issue using published scientific information and other information pertaining to the Stillwater NWR area.

Two livestock-grazing tours were conducted in which the Service received input from a variety of interest groups and professionals. The first meeting, conducted on July 7 and 8, 1997, was a review of the habitat management program by the Regional Office, Portland. Several professionals with expertise in rangeland and riparian systems (from the Agricultural Research Service and the University of Nevada-Reno) were invited to provide technical input. A report was produced by the Division of Operations Support, Regional Office that outlined recommended changes to the habitat management program of the Stillwater NWR Complex (Paveglio et al. 1997).

In the second meeting, July 19, 1997, other professionals and people representing livestock grazing interests and environmental interests were invited to attend the meeting. Participants included representatives from the Natural Resource Conservation Service, the Nevada Chapter of the Society for Range Management, Nevada Chapter of The Wildlife Society, Nevada Wildlife Federation, Great Basin Chapter of Sierra Club, and a private citizen. Several areas on Stillwater WMA, Fallon NWR, and Stillwater NWR were visited during the tour, and participants were asked to provide input on the livestock grazing issue.

Management Perspectives

<u>Livestock Grazing as a Tool to Achieve Refuge Purposes and Goals</u>

Whether a particular management tool is appropriate on a given refuge or other management area depends, among other factors, on desired conditions of the refuge, which is dictated by refuge purposes and other legal authorities. Purposes of Stillwater NWR and Fallon NWR have been stepped-down to proposed goals, and thus, these goals reflect the same desired conditions as the purposes and other legal mandates.

Draft goals of Stillwater NWR, which closely reflect the purposes of the refuge, are to (A) conserve and manage fish, wildlife, and their habitat to restore and maintain natural biological diversity; (B) fulfill international treaty obligations and international agreements with respect to fish and wildlife; and (C) provide opportunities for scientific research, environmental education, and wildlife-dependent recreation that are compatible with refuge purposes. Draft goals of Fallon NWR are to: (A) provide high-quality sanctuary and breeding habitat for migratory birds; (B) restore and maintain natural biological diversity; and (C) provide opportunities for wildlife-dependent recreation that are compatible with refuge purposes. Goals of Fallon NWR would only be adopted under Alternative A (No Action Alternative) and Alternative B of the EIS being prepared for Stillwater NWR Complex's comprehensive conservation plan. Because the area within Fallon NWR would be managed according to the purposes and goals of Stillwater NWR if it were to be incorporated into Stillwater NWR as part of the Stillwater NWR boundary revision, livestock grazing in this area is evaluated under both sets of goals. Furthermore, because the philosophy that Stillwater NWR should be managed primarily to benefit waterfowl has relatively strong support and because this has been the focus in the past, the potential use of livestock grazing as a management tool will also be evaluated against this philosophy.

Thus, one of the major questions addressed in this report is, "can livestock be used to effectively accomplish goals of Stillwater NWR and Fallon NWR under the existing ecological conditions of the refuges?" Whether livestock can be used to enhance wildlife habitat in a particular area depends primarily on (1) the wildlife management goals and objectives of the area; (2) environmental conditions of the area, especially those that influence plant growth and affect livestock distribution; (3) ecological health of soils and vegetation in the area; and (4) class of livestock being considered. Other factors that a manager should consider in determining whether livestock should be used to reach wildlife management objectives include limiting factors of targeted wildlife populations or communities, juxtaposition of habitats (relative to the extent to which livestock would remain in targeted habitats), the ecological processes with which native plant and animal communities evolved, impacts on habitat and non-target wildlife (i.e., side-effects), livestock distribution relative to distribution of target wildlife species, economic feasibility of using livestock to meet specific wildlife objectives relative to other options, availability of the required class of livestock, facilities and personnel needed to maintain adequate control over livestock, and the impacts of these facilities or activities on wildlife.

Ecological Perspective

Given the purposes for which Stillwater NWR must be managed (e.g., restoration of natural biological diversity; Public Law 101-618), an assumption of this report is that "Restoring and sustaining native wildlife communities requires that habitat conditions under which they evolved be restored and maintained, which in turn requires the restoration or emulation of the natural processes that maintained these conditions (Noss 1983, Samson and Knopf 1993, Noss and Cooperrider 1994)" (Nevada Chapt. of The Wildl. Soc. 1995). For the purposes of this report, natural ecological conditions in the Carson Desert are those conditions produced by the geologic, evolutionary, and other ecological processes operating in the Carson Desert, aside from human influences. This report also assumes that the variety of biotic processes, including their seasonal and annual variability in rates, levels, and extent is a component of biological diversity (Noss 1990, DeLong 1996, USFWS 1996). Therefore, not only must natural rates of herbivory be viewed as an ecological process leading to natural biological diversity, it is also a component of it.

A major assumption in restoring and maintaining the natural biological diversity on Stillwater and Fallon NWRs with respect to livestock grazing is that plant communities in the Carson Desert did not evolve under a substantial amount of grazing pressure by large ungulates, as is true of the Great Basin in general (Mack and Thompson 1982, Young et al. 1976, Miller et al. 1994). Burkhardt (1996) disputed this assumption as it pertains to the Intermountain West, including the Great Basin, arguing that vegetation of the Intermountain West evolved under the influence of Pleistocene megafauna until they became extinct. He further argued that extinctions were due to humans, and therefore the absence of these large ungulates is unnatural. However, the climate has changed substantially in the Great Basin since the Pleistocene. The gradual loss of relatively mesic plant species of the Pleistocene, due to a drying climate, corresponded with an increase in xeric species (Nowak, et al. 1994). The general trend in the Intermountain West climate during the last 2,000 years has been erratic, but increasing in aridity and an increased proportion of precipitation occurring during the winter (Antevs 1948, Morrison 1964 and Davis 1982 as cited in Miller et al. 1994). Miller et al. (1994) provides a detailed discussion of the climatic changes in Intermountain West vegetation during the past 10,000 years. Thus, it appears unlikely that the vegetation communities of the Great Basin today, even if they were in healthy condition, could sustain the Pleistocene megafauna. This is especially true in lower elevation areas such as the Carson Desert which only receives an average of 5 inches of precipitation per year. The hypothesis that humans caused the extinction of Pleistocene megafauna is receiving serious scrutiny (S. D. Livingston, Desert Research Institute, pers. comm., 1998).

The conclusion here is not that grazing, or herbivory in general, did not play an important role in the ecology of the Carson Desert and associated wetland ecosystem. It is quite possible that, the smaller herbivores, due to their large numbers, may have had a more substantial impact on the Intermountain West ecosystem than the large animals (Miller et al. 1994). In addition to native hoofed animals, there are many other herbivores that can have considerable impacts on plant community structure and composition: small rodents, lagomorphs (rabbits and hares), birds, insects, mites, and plant-parasitic nematodes (Young et al. 1979, Archer and Smeins 1991, Miller et al. 1994). For instance, in Stillwater Marsh, muskrats likely played a prominent role in vegetation structure. The effects that these herbivores have on vegetation communities, as well as those of native ungulates, can be much different than the effects of grazing by domestic livestock (Savory 1988, Stuth Smeins 1991).

Wildlife are a product of their habitat. Because processes shape habitat and habitat management essentially is the management of processes (Luken 1990), the principle that wildlife are a product of their habitat can be expanded to include the assessment that wildlife are a product of processes that shape habitat, including habitat management practices. This principle is important because it influences decisions on the type of vegetation manipulation practices that would be needed to produce the type of habitats that are identified in Refuge goals and objectives. For instance, a natural diversity of wildlife would result in part from the approximation of natural habitat conditions, which are created and maintained by allowing for or mimicking the natural functioning of ecological processes (Noss and Cooperider 1994). Therefore, because the approximation of natural habitat conditions is a focus of Stillwater NWR management, livestock grazing as a habitat management tool must be evaluated in the context of the processes that created and maintained natural habitat conditions of the Lahontan Valley.

In order to evaluate the usefulness of habitat management methods for accomplishing Refuge goals, we needed to understand the processes that created habitat conditions under which native wildlife communities evolved. Of primary concern are the processes of succession, soil erosion, soil formation, and disturbances such as fire, herbivory, and mechanical disturbance (including hoof action). Although uncontrollable, climatic conditions also are important. In particular, hydrology historically influenced vegetation to a large degree in the Lahontan Valley (Appendix F), whereas grazing by large herbivores played a limited role in influencing habitat conditions prior to the introduction of domestic livestock (based on Mack and Thompson 1982; and Young et al. 1976). These two processes are noteworthy because they are two of the primary habitat management practices being evaluated in this Draft EIS, and because significant alteration of water flows and introduction of livestock has had dramatic impacts on vegetation within refuge borders.

1948-1998 Livestock Grazing Program

Livestock grazing in the area of Stillwater WMA prior to 1948 was characterized by Wiseman (1962:3) as follows: “Due to a lack of any grazing control on the affected public lands, the Area was used on a free range basis, with the ‘toughest’ getting the ‘mostest’. Close [severe] grazing was the rule as no one wanted to see any feed ‘go to waste’... In the era immediately preceding the leasing of the Area to the Fish and Wildlife Service and the Nevada State Fish and Game Commission, the Truckee-Carson Irrigation District had made an effort to effect some control of the grazing. Truckee-Carson Irrigation District’s program to regulate grazing was largely ineffective...”

Since November 26, 1948, livestock grazing on Stillwater WMA, Stillwater NWR, and Fallon NWR has been managed according to direction provided in the Tripartite Agreement that established Stillwater WMA. The Tripartite Agreement is a 50-year agreement between the Truckee-Carson Irrigation District (as contractor of the Newlands Irrigation Project for the U.S. Bureau of Reclamation), Nevada State Board of Game Commissioners (now the Nevada Division of Wildlife), and the U.S. Fish and Wildlife Service. The agreement stated that livestock grazing would be managed “commensurate” with the primary purposes of the area, which were to conserve and manage wildlife, provide a public hunting area, and to establish and maintain a sanctuary. According to the Tripartite Agreement, the maximum amount of livestock grazing to be permitted on the area was to be determined annually, “having due regard for the condition of the range, and the wildlife requirements thereon.”

The first livestock grazing plan was completed in 1951 by D. Marshall (Marshall 1951). He classified livestock grazing into 3 types: desert, marsh, and irrigated pasture. Saltgrass was identified as the most important forage species, but Marshall also noted that rushes and cattail received heavy use in the spring. Marshall argued that spring grazing by livestock was needed to maintain Stillwater Marsh's status as a nesting area. In 1951, the Service anticipated developing about 3,000 acres of irrigated pasture.

Marshall noted that, even in the best of years, much of the "desert" is too far from water to provide grazing opportunities, and that forage production in accessible areas is poor. Thus the desert area "offers little more than supplemental grazing" (Marshall 1951:1). In developing the 1951 livestock grazing plan, Marshall assumed that "With the possible exception of the Stillwater Marsh, heavy grazing does not seem to be detrimental to wildlife. Grazing can not hurt the desert" (Marshall 1951:1).

Marshall recommended two grazing periods for Stillwater WMA exclusive of Stillwater Marsh: April 1 - October 31 (4,500 AUMs) and November 1 - March 31 (1,300 AUMs). The grazing period identified for Stillwater Marsh was April 1 - October 31 (400 AUMs during April 1 - July 15, and 800 AUMs during July 16 - October 31). He also recommended that Indian Lakes, Pelican Island marsh, and Stillwater Marsh be fenced separately. According to Marshall (1951), there were 50 separate operators. Livestock grazing permits were first issued by the Service in 1952 (Wiseman 1962).

A range survey was completed in 1955 (Rouse 1955). The focus of the *Range Survey Report* was on the estimation of the grazing capacity of Stillwater WMA, including Stillwater NWR and Fallon NWR. Rouse divided Stillwater WMA into 20 units, mostly in Stillwater Marsh, for the purposes of his study. In total, he estimated the grazing capacity at 4,150 AUMs for Federal lands in what is now Stillwater NWR, Stillwater WMA, and Fallon NWR. This compares to about 11,000 to nearly 18,000 AUMs/year of livestock grazing use during 1957-1961 (which appears to have been about the same amount of grazing use that occurred at the time Rouse conducted his survey). According to Rouse (1955), there were 19 livestock grazing permittees using Stillwater WMA in 1955. In his concluding remarks, Rouse (1955:29), surmised that "While the permitted use of the entire Management Area is greater than the estimated grazing capacity obtained by this survey, it is not believed necessary to make any reductions in the numbers of livestock at this time," and that "The marsh does not show indications of over-use." However, he did note that "The upland forage areas have been over-used for many years and the more palatable grasses have largely disappeared."

Rouse stressed that dividing the area into livestock grazing units was needed to properly control and manage livestock. He surmised that "Under present conditions, management of livestock use on the area is handicapped by lack of controls" (Rouse 1955:30). Despite his repeated references to additional fencing, he concluded that "Fences to enclose [the Pauite Management Unit] would then be justified. The balance of the Management Area, as can be foreseen at this time, would not derive sufficient benefit from the control of livestock to justify fencing that would be required," likely basing this assessment on the capacity of the entire 163,072-acre area being a mere 4,150 AUMs/year. Another of Rouse's recommendations was the construction of several short canals and other water-control facilities for spreading water to increase forage production. He noted that these "improvements" would also increase waterfowl habitat. Rouse also recommended delaying spring turn-out to May 15 in upland areas supporting ricegrass and other bunchgrasses, but noted that "Local graziers may object to holding their stock until this late as they usually do not have sufficient spring pasture to carry them from the end of the feeding period until they can turn them out on the range." Spring turn-out continues to be about April 1.

In 1960, a working agreement was signed by the Nevada State Board of Game Commissioners (now Nevada Division of Wildlife) and the U.S. Bureau of Sport Fisheries and Wildlife (now the Service). Under the agreement, the area now within Stillwater NWR (Area 1) was to be "developed and managed primarily for wildlife with collateral benefits for grazing." Conversely, it was agreed that the area now within Stillwater WMA and the south end of Fallon NWR (Area 2) was to be "developed for grazing by water spreading with collateral benefits for wildlife." It further stated that "During the spring and early summer priority on water use will be given to the management of the entire area for the production of waterfowl and waterfowl food, and for irrigation of pasture."

Because the 1962 Economic Use Plan provided the most detail on the livestock grazing program, integrating information from Marshall (1951) and Rouse (1955), and because it was the last plan written for the area on livestock grazing management, it is summarized at some length. The 1987 Management Plan for Stillwater WMA only minimally addressed livestock grazing.

A revised livestock grazing plan (*Stillwater Wildlife Management Area Economic Use Plan*) was completed in November 1962 (G. Wiseman 1962). One of the key elements of the plan was the maintenance and further development of irrigated pastures. Wiseman noted that the Service and the then Nevada Fish and Game Commission had spent about $250,000 on intensively developing about 2,500 acres of irrigated land (East Pasture, Paiute Pasture, and West Pasture). Apparently, full utilization of these pastures was limited by insufficient water, for which he blamed the Truckee-Carson Irrigation District for demonstrating "poor faith" (under the Tripartite Agreement) with respect to delivering water to the pastures and negotiating for water rights for them. Wiseman suggested that the purchase of water rights for irrigating pastures was essential to maintaining Stillwater WMA for waterfowl management.

Whereas Wiseman (1962) noted additional fences that had been constructed since Rouse's (1955) report, he stated that additional fencing was needed to improve livestock grazing management on portions of the area (i.e., to provide for "proper utilization"). However, he assessed that an extensive program to cross fence the marsh and other parts of Stillwater WMA did not appear feasible given the unreliable water supply.

This paragraph and the following three paragraphs summarize material from the 1962 Economic Plan that portrays further the philosophies of livestock grazing management on Stillwater WMA. With respect to setting year-to-year stocking limits, Wiseman (1962:13) stated that it had become established policy to recognize the need of each permittees for a given amount of grazing use each and every year, and that this "policy" would be followed to the extent that it is possible to correlate individual needs with available forage. In recognition of fluctuations in forage availability from year-to-year, the Economic Plan specified that permit allotments may be increased in years of "feed abundance." Conversely, no provisions were specified to reduce grazing use during drought years, except that the Service would "encourage" voluntary reductions by permittees and would take advantage of attrition of former unrenewed permits when this corresponded to drought conditions.

Wiseman (1962:15) noted that "Historically, the Area has been utilized for grazing year around, with most use occurring from April 1 to November 30. As a measure to support the existing economy, this historic pattern of use has continued under administration by [the Service]." He continued by asserting that "It shall be continuing policy to allow year around use on the native range areas. On seeded and irrigated pastures period of use shall be May 1 to October 31 inclusive." Aside from a different use period on pastures, this practice continues today.

Continued "close use" by livestock and minimal efforts to control livestock grazing, aside from non-renewal of expired permits, may be in part due to the assumption that the main forage species were highly resistant to livestock grazing pressure. For example, Wiseman (1962:14) presented the following conclusions based on "consultation with local and national range authorities, together with personal observations." He surmised that the "primary forage species in the area are almost totally immune to adverse effects resulting from cattle grazing use... Annual plants support a large percent of the grazing load when local precipitation makes these available. Obviously, these annual plants, mainly Russian thistle and alkali weed, are not subject to any adverse effects from grazing."

Wiseman (1962:14) recognized that there were several native species of plants that are adversely impacted by "close grazing use." However, he concluded that "it seems obvious that it is not feasible to regulate grazing to favor a few scattered plants of Indian ricegrass or spiny hopsage, which might show more vigor under lighter stocking rate. In this desert region the impracticality of this is obvious." He further noted that it is imperative to regulate livestock grazing so that it is compatible with waterfowl management. To this end, Wiseman state that "Grazing use shall be maintained at a level designed to benefit waterfowl by creating open shoreline situations, but shall not be pursued to the extent that excessive competition for food and cover occurs." Nothing was said about the relationship between season-long close grazing use and quality of waterfowl nesting cover.

Based on operating experience, Wiseman prescribed the maximum annual stocking limit at 24,000 AUMs for Stillwater WMA. This included unfenced lands to the south (Ole's Pond and S-Line Reservoir, which were operated as one unit with Indian Lakes. It also assumed irrigation of East Pastures and Paiute Pastures. In setting this maximum level, nothing was said of Rouse's range survey that indicated the grazing capacity to be just over 4,000 AUMs for roughly the same area. In the "Grazing Management Objectives" section, objectives were expressed in terms of facilitating and increasing forage potential in irrigated pastures. Livestock grazing objectives for the remainder of Stillwater WMA were to: (1) gain more control over livestock grazing through additional fencing, (2) increase permittee's interest in range improvements, and (3) decrease the downsides of community grazing (e.g., permittee bickering, cattle rustling, unnecessary hazing of cattle, among other examples listed). The 1962 Economic Plan did not identify any objectives in terms of range condition (i.e., "...having due regard for the condition of the range, and the wildlife requirements thereon" as stated in the Tripartite Agreement) or to ensure compatibility with waterfowl management.

Wiseman (1962) reported on several artesian wells that provide stock water. Three artesian wells at the delta of the Carson River (on Fallon NWR) were developed in the 1930s as a drought relief measure. Other artesian wells exist: (1) at the north end of Timber Lake, (2) between Cottonwood and East Lakes, and (3) near the Carson River near Papoose Lake. Understandably, salting was ruled out as a practice to increase livestock distribution due to naturally occurring salt deposits and salts associated with forage in the area.

Just as pre-1948 efforts of the Truckee-Carson Irrigation District to control grazing in the area of Stillwater WMA may have been ineffective (Wiseman 1962), it does not appear that the Service has faired much better, except that livestock use of the area has declined over the years. "Close grazing use," "over-use of upland areas," "disappearance of the more palatable grasses," and "lack of livestock grazing management controls [i.e., fencing]," characteristic of pre-Stillwater-WMA-establishment, and the 1950s and early 1960s (Rouse 1955, Wiseman 1962) continue despite a drop in livestock use of the area. Nearly year-long grazing also characterize the existing livestock grazing program. Declining forage consumption by livestock on Stillwater WMA has been due to permits not being reissued as permits are retired and permittees not using their entire allocations. Until the late 1980s, livestock use remained at relatively high levels (e.g., 9,000-11,000 AUMs). In recent years, livestock grazing use has been about half of what it was during the 1950s. It totaled 6,843, 6,531, 6,879, and 7,323 AUMs in 1994, 1995, 1996, and 1997, respectively. Even with these reductions, this amount of use is above the maximum amount recommended by Rouse in 1955.

EFFECTS OF LIVESTOCK GRAZING ON STILLWATER NWR COMPLEX

Livestock grazing effects on native wildlife and vegetation of the Stillwater area range from beneficial to detrimental. An important factor that must be considered in evaluating the effects of livestock grazing on a given ecosystem is the goals of the area. Under one set of goals, the effects of a certain livestock grazing program could be beneficial by contributing toward achieving the goals. The same livestock grazing program, under a different set of goals, could be deleterious by hindering or diminishing the ability to achieve the goals. This factor is especially pertinent to the Stillwater NWR Complex given the shift in management purposes required by Public Law 101-618.

WILDLIFE

Most effects of livestock grazing on wildlife take place through livestock grazing's effects on wildlife habitat. However, direct impacts of livestock on wildlife do occur. For example, some species of birds (e.g., cattle egrets, ring-billed gulls) are attracted to cattle activity, capturing insects stirred by cattle moving about. Inadvertent trampling of nests by livestock has been documented (Gjersing 1971, Koerth et al. 1983), although not thought to be a major factor affecting nest success. Livestock displacement of mule deer has been reported in habitats such as riparian areas (Rule 1989, Kie et al. 1991). Holechek et al. (1995:362) noted that social aversion to livestock by mule deer may be of minor importance at light or moderate stocking rates.

Aside from effects on habitat, potentially the greatest direct impact of a livestock grazing program on wildlife is the fences used to control livestock. Location and design of fences influences magnitude of impact (Spillett et al. 1967, Kindschy et al. 1982). Potential impacts of fences on wildlife are probably highest in riparian and emergent marsh habitats, where wildlife activities are concentrated (Thomas et al. 1979, Maser et al. 1984a) and where the need for fencing to control livestock distribution traditionally is greatest (Platts 1989). Some of the wildlife known to have been killed by hitting fences include pelicans, herons, egrets, coots, and waterfowl (Annual Narrative Reports, Refuge files).

WATER QUALITY

Livestock use in uplands can affect water quality directly by increasing sediment loading and coliform bacteria counts in overland runoff, and indirectly through the impacts they have on vegetation (Blaisdell et al. 1982, Minshall et al. 1989). Sediment loading can increase through increased soil disturbance and disruption of mycrophytic crusts (St. Clair et al. 1993). Livestock can reduce water quality by trampling banks and defecating in streams (Dunne and Leopold 1978:740, Platts and Nelson 1985). Indirect effects of prescribed burning, haying and livestock grazing on water quality relate to the extent to which they influence vegetation attributes. Changes in vegetation leading to increased sedimentation can decrease water quality of streams (Platts and Nelson 1985, Clary and Webster 1989, Minshall et al. 1989).

SOIL

Riverine-riparian, Marsh Shoreline, and Meadow

Direct impacts of livestock grazing on soils can include trampling of streambanks and reduction of infiltration rates from soil compaction. Damage to streambanks is reported where banks have been de-stabilized by excessive livestock use (Clary and Webster 1989, Armour et al. 1991). The probability of damage to streambanks from livestock use is related to several factors including: (1) characteristics of streambanks and adjacent stream channels; (2) type and condition of streambank vegetation; and (3) success of control over the timing, intensity, and duration of livestock use (Clary and Webster 1989, Platts 1989; Myers and Swanson 1991). Streambanks with coarse-textured soils are less prone to damage from livestock use than streambanks with fine-textured soils (Myers and Swanson 1991).

Livestock grazing can indirectly influence soils by changing vegetation vigor and composition. The amount of unstable streambank is related to composition of streambank soils, composition of streambank vegetation, and intensity of livestock use (Clary and Webster 1989, Platts 1989). Intensive use of sites by livestock can increase probability of streambank damage by reducing composition of deep-rooted sedges and willows and increasing composition of shallow-rooted grasses (Kovalchik 1987, Kovalchik and Elmore 1992). Sedges and rushes have been shown to hold stream-side soils better than grass-dominated communities (Dunaway, et al. 1994, Swanson 1996), and sedge species such as Nebraska sedge (*Carex nebrascensis*) appear to have the greatest ability to hold streambank soils intact (Kleinfelder et al. 1992). Increased infiltration rates and decreased soil compaction have been associated with non-use by cattle and a rest-rotation cattle grazing system, as compared to more traditional livestock grazing strategies which appeared to hinder recovery of infiltration and soil compaction (Bohn and Buckhouse 1985). After one year of research, Hayes (1978) reported that rest-rotation cattle grazing in central Idaho did not significantly accelerate channel movement by bank degradation. In other instances, certain rest-rotation practices appear to have allowed riparian areas to begin recovering (Meyers and Swanson 1995, Masters 1996).

Non-structural and structural management practices are used to restore streambanks and channels. Non-structural methods include rest from livestock grazing (Clary and Webster 1989) and increased control over livestock use (Platts 1989, Masters et al. 1996). Although it is well documented that adjustments to livestock grazing programs can reduce adverse impacts to riparian soils and vegetation, and thus allow recovery to occur, these adjustments do not rival the recovery that occurs from completely excluding livestock from riparian corridors (Clary and Webster 1989, Platts 1989, Platts 1990). Structural techniques include planting willow (McCluskey et al. 1983), installation of juniper revetments (Sheeter and Clair 1981), and construction of check-dams (Heede 1966).

Uplands

In general, impacts to upland soils may be limited on the Stillwater area, except on sites where concentrated use has occurred. Disturbance of the soil surface in some vegetation types, especially where mycrophytic crusts occur, can lead to increased soil erosion potential (St. Clair and Johansen 1993, St. Clair et al. 1993). Indirect effects stem primarily from the influence of livestock grazing on ground cover and vegetation composition.

Rest from livestock grazing in upland areas would not result in substantial change in composition of plant communities or soil characteristics where shrub cover is excessive (Winward 1991, Laycock 1991). Higher soil erosion rates and lower water-infiltration rates have been recorded on sites with excessive shrub cover compared to sites with less shrub cover and more ground cover (Blaisdell et al. 1982).

COMPOSITION AND STRUCTURE OF VEGETATION

Riverine-riparian, Marsh Shoreline, and Meadow

Livestock grazing has been a major contributing factor to significantly altered composition and structure of riparian areas, including riparian meadows, throughout the intermountain West (Thomas et al. 1979, Platts et al. 1989, Elmore and Kauffman 1994, Kie et al. 1994, Dobkin et al. 1998). Livestock grazing can reduce the vigor of native vegetation along streambanks (Pond 1961, Knopf and Cannon 1982, Skovlin 1984, Kovalchik and Elmore 1991). When plant vigor of streambank vegetation is consistently reduced, it begins to be replaced by vegetation more resistant of grazing pressure (Pond 1961, Kovalchik and Elmore 1991). Reduced vigor and altered species composition of plant communities can result in increased streambank erosion because of reduced root-mass and binding ability of streambank vegetation in alluvial valleys (Clary and Webster 1989, Gebhardt et al. 1989, Kleinfelder et al. 1992, Dunaway et al. 1994). Consequently, streambanks become less resistant to high water flows, banks erode, the channel-form changes, and water tables drop in alluvial valleys (Van Havereen and Jackson 1986, Gebhardt et al. 1989, Leonard et al. 1992). Lowered water tables contribute further to reduced cover of native riparian vegetation and increased cover of native upland plants (e.g., big sagebrush) that are tolerant of dry soils (Elmore and Beschta 1987) as well as non-native grasses that have limited soil-binding potential (e.g., timothy, cheatgrass). Under these conditions, stream channels continue to erode until a new floodplain becomes established at a lower base level (Van Havereen and Jackson 1986, Gebhardt et al. 1989). No benefits of livestock grazing in riparian areas were identified in the July 1997 Habitat Management Workshop, except for the possible use of sheep in controlling noxious weeds (Paveglio et al. 1997).

Adjustments to livestock grazing practices can allow recovery to begin in riparian areas (Clary and Webster 1989, Meyers and Swanson 1995, Masters et al. 1996). For example, implementation of deferred rotation cattle grazing in central Nevada, following years of season-long cattle grazing, allowed the studied riparian areas to begin recovering. In the study, riparian areas that were completely rested from livestock grazing and absent any roads had the highest recovery rates, followed by riparian areas under a deferred rotation system absent any roads in the riparian area. Riparian and shrub cover increases were highest in the areas where livestock were completely excluded. After three seasons of cattle being excluded from two exclosures in the Carson River floodplain and delta on Stillwater WMA, preliminary observations indicate a considerable increase in plant species diversity (R. Bundy, Stillwater NWR, pers. comm., 1999).

Although livestock grazing has likely contributed toward degradation of the lower Carson River riparian area, significantly altered hydrology in the Stillwater area (Kerley et al. 1993) has been the major factor. Another major factor has been the introduction and spread of invasive plant species such as saltcedar, which . However, continued livestock grazing has the potential to hamper efforts to restore the geomorphology and riparian vegetation of the lower Carson River. By slowing or inhibiting the recovery of native riparian vegetation, livestock grazing would hinder progress toward restoring natural biological diversity, a major purpose of Stillwater NWR (Public Law 101-618, § 206(b)(2)).

On Stillwater WMA and Fallon NWR, reduced vigor of native riparian vegetation has also likely contributed to high densities and canopy cover of saltcedar. Thus, while livestock grazing is not the cause of saltcedar being introduced to the area, it likely has contributed to the significantly altered species composition and structure of plant communities. In the meadow habitat associated with the delta of the Carson River, large portions of the plant community have changed from a mixture of grasses, rushes, forbs, and sedges to domination by saltcedar. Eventually, if left unchecked, saltcedar can form monotypic stands. If factors reducing the vigor of native vegetation (e.g., inadequate water availability; season-long, heavy livestock grazing) are not corrected, expansion of perennial pepperweed (tall white-top) will be also facilitated.

Negative effects to wildlife usually are associated with (1) temporary removal of cover required by species for reproduction and concealment (Kirsch et al. 1978, Medin and Clary 1990, USFWS 1990, Kantrud 1990); and (2) frequent, intensive removal of vegetation that results in long-term alteration of stream channel geomorphology, and, consequently, diminished area of the riparian wetland (Winegar 1977, Thomas et al. 1979, Gebhardt et al. 1989, Schulz and Leninger 1991). With respect to item number 1, above, the "temporary" removal of vegetation occurs for most of the year on Stillwater WMA and Fallon NWR, and thus has resulted in nearly year-round depletion of cover.

The effects of livestock grazing on meadow vegetation were studied along the lower Carson River in Fallon NWR. Near Battleground Point, five sample plots located inside a 1-hectare livestock grazing exclosure and four of five sample plots located outside the exclosure were characterized in April 1997 as a saltgrass dominated plant community with few other species present. From April 1997 to September 1999, sample plots within the exclosure changed to a more native mix of plant species, with a higher diversity of plant species within the community, while the outside sample plots retained the same vegetative composition throughout this period (Table 1) (Bundy and DeLong, U.S. Fish and Wildlife Service, Unpubl. Data). The number of species within plant communities, the average amount of the ground covered by vegetation, and the average height of plants within the sample plots were roughly at the time the livestock grazing exclosures were constructed (2.4/3.6 species, 15%/13% ground cover, and 10cm/12cm average height, for inside plots/outside plots respectively), but, these values had changed to 8.4/4.8 species, 72%/61%, and 44cm/20cm by September 1999. Compositional differences were not as apparent on an exclosure located roughly one mile south of the one near Battleground Point. The southern area had fewer grasses and more shrubs, which would not be expected to change to the same degree over the three year sample period.

Concealment cover near ground level (e.g., up to 6-½ inches) was measured inside and outside the north and south livestock grazing exclosures. Concealment cover was estimated using a 6-½x6-½" cover board divided into 25 squares with 4 dots each (100 points). At the time the exclosures were constructed in April 1997, concealment cover below 6-½ inches was nearly equal between the inside and outside plots for both the northern and southern exclosures (Figure 1). After one growing season, concealment cover remained unchanged outside the livestock grazing exclosure, but increased inside the exclosure at both locations. By the end of the third growing season, concealment cover had more than doubled inside the exclosure, but still had not changed outside the exclosure.

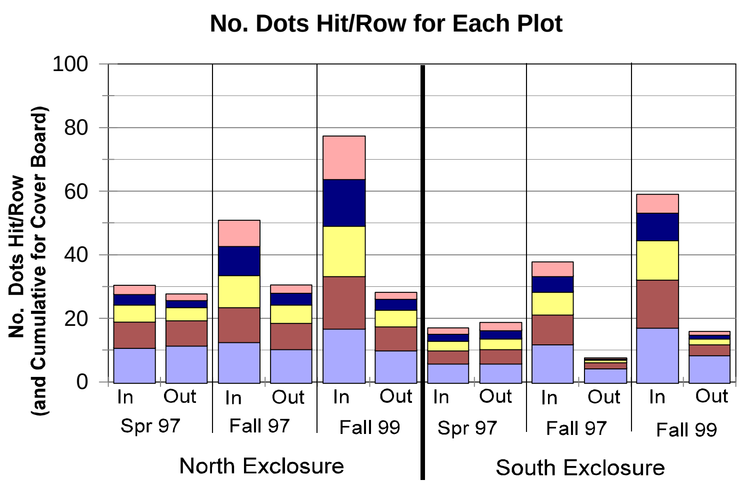

Figure 1. Graph illustrating the difference in concealment cover inside and outside of two livestock exclosures, during three sampling periods following construction of the exclosures (May 1997), Fallon National Wildlife Refuge, Nevada. Each vertical cell in bars represents cover at 1.3 in. height intervals from lowest (bottom) to highest.

Because livestock can alter the vegetative structure of plant communities, increasing it in some cases (Holechek et al. 1995, Severson 1990, and Kie and Loft 1990), they can benefit some species of wildlife. Holechek et al. (1995:357) stated that livestock can be selectively grazed to open up dense stands of vegetation. Kie and Loft (1990) cited several studies that indicate that cattle can be used to create tunnels through shrub vegetation (e.g., willow stands). They also cited two studies that put forth evidence that modifying the structure of shrub stands can benefit some species of wildlife. However, native shrubs (e.g., willows, wild rose, buffalo berry) are nearly absent on the Stillwater area, thus nullifying consideration of this application for many years to come. I am unaware of any documentation of cattle being used to open-up mature stands of saltcedar.

Table 1. Community type (as characterized by Bundy et al. 1996), number of species (SP), total canopy coverage (CC), and average height (HT) for 2 grazing exclosures (north - N, south S) and 20 sample plots (inside - I, outside - O) measured near Fallon NWR, 1997-1999 (Bundy and DeLong In Prep.).

	April 1997				September 1977				September 1999			
PLOT	**Community**	**SP**	**CC**	**HT**	**Community**	**SP**	**CC**	**HT**	**Community**	**SP**	**CC**	**HT**
NI30	Saltgrass	2	16	4	Saltgrass/Mallow	5	48	27.6	Saltgrass/mixed forb	12	78	39.3
NI37	Saltgrass	4	8	15.8	Saltgrass	15	100	28.9	Saltgrass	5	100	54
NI45	Saltgrass	1	10	14	Mixed Meadow Grass	11	74	33.9	Saltgrass/Baltic Rush	8	88	40
NI48	Saltgrass	3	12	9.3	Mixed Meadow Grass	13	86	28.6	Mixed Meadow Grass	13	92	46.2
NI96	Saltgrass	2	31	8.5	Saltgrass/Bassia	3	28	40.3	Saltgrass	4	4	39
NI	Average	2.4	15	10	Average	9.4	67	32	Average	8.4	72	44
NO05	Saltgrass	3	12	5.3	Saltgrass	5	67	11.8	Saltgrass	7	63	18.3
NO11	Saltgrass	2	9	15	Mixed Meadow Grass	2	92	24	Saltgrass	2	96	25
NO49	Saltgrass	2	9	8	Saltgrass	2	17	15	Saltgrass	1	45	14
NO88	Saltgrass	6	17	13	Saltgrass	2	26	28	Saltgrass	4	73	23.8
NO97	Mixed Meadow Grass	5	18	19.8	Mixed Meadow Grass	10	24	12.1	Mixed Meadow Grass	10	29	16.4
NO	Average	3.6	13	12	Average	4.2	45	18	Average	4.8	61	20
SI02	Mixed Meadow Grass	12	46	18.6	Mixed Meadow Grass	11	47	38.4	Saltgrass/Baltic Rush	9	55	49.4
SI18	Mixed Shrub	6	64	42.2	Mixed Shrub	6	49	74.2	Greasewood/Saltgrass	6	83	57.8
SI27	Rabbitbrush/Mixed Forb	17	48	17.9	Rabbitbrush/Mixed Meadow Grass	9	62	53.9	Mixed Meadow Grass	16	85	51.3
SI32	Saltgrass/Bassia	6	50	19.5	Saltgrass/Bassia	4	48	63	Mixed Meadow Grass	5	92	35
SI33	Saltgrass	1	35	13	Saltgrass	2	44	28	Saltgrass	2	71	23.5
SI	Average	8.4	49	22	Average	6.4	50	52	Average	7.6	77	43
SO01	Mixed Meadow Grass	10	69	38.2	Saltgrass	7	28	31.6	Saltgrass	6	55	18.8
SO22	Tamarisk	1	33	22.1	Tamarisk/Mixed Meadow Grass	2	76	37.6	Tamarisk/Saltgrass	2	68	38.4
SO39	Four-wing Saltbush	6	43	33.3	Four-wing Saltbush	5	28	29.2	Four-wing Saltbush	3	26	71
SO48	Mixed Shrub	6	27	46.8	Mixed Shrub	5	43	49	Mixed Shrub/Saltgrass	3	33	59.3
SO62	Mixed Meadow Grass	11	32	18.9	Saltgrass	5	19	28.4	Saltgrass	9	70	27.7
SO	Average	6.8	41	32	Average	4.8	39	35	Average	4.6	50	43

Whereas wildlife species that prefer relatively dense and tall meadow vegetation (graminoid dominated) would be positively impacted by reductions in or elimination of cattle grazing from along the Carson River and meadow areas in Stillwater WMA and Fallon NWR, species that prefer low statured vegetation in meadows could be adversely impacted when vegetation recovers. Height of vegetation in meadow habitat grazed by cattle in Stillwater WMA and Fallon NWR has been far below the 12 inches used by Kie and Loft (1990) as a cut-off between short and tall vegetation in meadows. Characteristic height of herbaceous vegetation along the Carson River and associated meadow habitat in these two areas is 3-6 inches or less.

Given available information, I agree with Kindschy's (1987, as cited in USBLM 1991b) assessment that, "in essence, livestock are NOT 'a tool' to improve riparian ecosystems. Rather, they are a cost that may often be accommodated and still enable successional advancement of riparian vegetation and attendant functional values." Although recovery of many riparian areas can proceed under a carefully managed livestock grazing program, the most effective solution is the exclusion of livestock from riparian areas (Kaufmann and Krueger 1984, Platts 1990, Kovalchik and Elmore 1992, Buckhouse and Elmore 1993, Chaney et al. 1993).

<u>Effects on the Habitat of Specific Groups of Wildlife</u>

Waterfowl, Shorebirds, and Other Waterbirds

Effects of livestock grazing ranges from beneficial to detrimental, depending on the actual grazing practices, condition of the vegetation, desired conditions, and other factors. Species that use meadows, pastures, or shorelines with short vegetation and bare ground (e.g., killdeer, mountain plover) can benefit from livestock grazing, so long as the grazing does not contribute to the conversion of the plant community to saltcedar or other invasive non-native plants.

The Blitzen Valley Management Plan for Malheur NWR (USFWS 1990:143-144), reported that impacts of livestock grazing on breeding waterfowl on the refuge were indirect because cattle were grazed primarily in the fall or winter. The plan listed several benefits of grazing meadows by cattle: (1) habitat diversity and patchiness, (2) increased chances of successful germination of seeds, (3) cattle dung can host invertebrate wildlife which can be used by other wildlife, (4) it can stimulate growth of new vegetation. Only the first benefit was accompanied by a literature citation. Preliminary findings of a study conducted on Malheur NWR (USFWS 1990:144) suggest that meadow areas that were rake-bunch grazed had higher numbers of ducks and geese present on them during April-May as compared to meadow areas that were left idle. However, in another study, excluding grazing and restricting mowing to late summer resulted in ducks nesting earlier and in higher densities of nesting ducks (Clark 1977). When grazing and mowing were excluded, duck production increased.

In general, livestock grazing is detrimental to waterfowl nesting. Kirsch (1969), after reviewing waterfowl literature, suggested that "cover removal such as regular grazing and mowing should be discontinued on areas managed primarily for waterfowl production and that management practices that create dense rank cover be substituted." He recommended that periodic burning or soil disturbance be tested as a means to create dense, rank cover. In reviewing the literature, Kirsch was unable to find a single example of where livestock grazing increased waterfowl production. Strassmann (1987), in reviewing livestock grazing and haying programs of 123 NWRs, concluded that "there is solid evidence that cattle grazing is harmful to all species of ducks that managers believed to benefit from grazing." Braun et al. (1978, as cited by USFWS 1990) reported that at least 55 studies on waterfowl have demonstrated that livestock grazing can be detrimental to waterfowl production and that they knew of only one study that reported higher nest success in areas moderately grazed by livestock compared to idle lands. Holechek et al. (1989:353) noted that grazing by livestock, at even light intensities, appears to be harmful to nesting waterfowl, with some exceptions. Conversely, Marshall (1951) alleged that the highest nesting concentrations on Stillwater WMA occurred in the Indian Lakes, an area of heavy to severe livestock grazing pressure. He surmised that adjoining desert shrub growth provided ample nesting cover. However, this assessment was not accompanied by supportive data. Marshall (1951) identified another benefit of heavy livestock grazing in the Battleground wetland area. According to Marshall, the grazing pressure effectively eliminated waterfowl nesting in the area, which was considered beneficial because the marsh dries quickly and “the broods would die for lack of water.”

Kirby et al. (1992) reviewed the literature on the effects of livestock on breeding waterfowl. They found no evidence from appropriately designed studies to indicate that livestock grazing benefits upland nesting ducks. Some circumstantial results from poorly designed experiments suggest the opposite. However, they went on to say that livestock grazing should remain in the manager's tool kit, but that the status of wildlife habitat and refuge objectives must define the need for a particular grazing regime. They also made the assessment that if immediate restoration of riparian habitat is the goal, "no measure would will be as successful as completely excluding livestock." After analyzing 26 years of duck nesting data in relation to livestock grazing and other habitat management practices on Monte Vista NWR, southern Colorado, Gilbert et al. (1996) concluded nest densities consistently were still depressed 3 years after grazing and that nest success declined as grazing intensity increased. Whereas Peek (1986:198) stated that the influence of livestock grazing activities on waterfowl range from positive, to neutral, to detrimental, the only benefit of livestock production that Peek pointed out is the development of stock-watering impoundments in arid regions of the West. This benefit, however, does not pertain to livestock grazing as a process.

In literature reviews on the effects of livestock grazing on wildlife species of interest at Greys Lake NWR, Minidoka NWR, and Camas NWR, Idaho, Bouffard (199?) found that the adverse impacts of livestock grazing generally outweigh any benefits to waterfowl production. In his literature reviews, Bouffard noted that livestock grazing affects upland nesting ducks more than over water nesters, due to the impact livestock have on reducing tall, dense cover in upland areas.

Some of the published papers that describe the benefits of livestock grazing to waterfowl nesting include the following. Holechek et al. (1982, as cited by Strassmann 1987) report that limited burning or grazing every 1-3 years increases blue-winged teal production in Iowa and South Dakota. Sedivec (1990) reported that waterfowl nesting success was higher in grazed areas as compared to non-grazed areas in North Dakota prairie potholes. A study cited by Kirsch (1969) reported higher nesting success of blue-winged teal in moderately grazed areas compared to ungrazed areas. However, Kirsch pointed out that most of the ungrazed areas that contained nests consisted of narrow strips or clumps of idle land, that were later shown to be more vulnerable to predation. Furthermore, Stillwater NWR is outside of the breeding range of blue-winged teal.

Severson (1990), in summarizing a symposium on the use of livestock as a wildlife-habitat management tool, qualified the use of livestock grazing to manage waterfowl habitat by stating that "...it is easier to visualize how livestock could be used to manage vegetation in the Northern Great Plains [in contrast to the American Southwest]. The primary reason is that the vegetation of the Plains evolved under significant grazing pressure by large ungulates; whereas that in the Southwest did not. The logic employed by Kantrud (these proceedings) in his assessment of using prescribed cattle grazing and prescribed fire as replacements for bison and wildfire, to manage waterfowl habitat in the Prairie Pothole region of the Great Plains, is correct for that region. However, the same logic should be cautiously applied to other regions, such as the mountain wetland "cienagas" of the Southwest." Similar to the Southwest, vegetation of the Great Basin did not evolve under a substantial amount of grazing pressure by large ungulates (Mack and Thompson 1982, Young et al. 1976). This is especially applicable to Stillwater NWR given the mandate to restore and maintain natural biological diversity (Public Law 101-618, Subsect. 206(b)(2)).

In cases where maximizing duck production is a major goal, Gilbert et al. (1996) recommended that actions only be taken to reduce residual vegetation when the residual vegetation is "so dense as to insulate the soil and block light penetration, thereby reducing new growth." They noted further that "A long recovery time is needed to restore residual vegetation removed by these actions. On Monte Vista NWR, they estimated through extrapolation that the frequency of vegetation-reduction treatments should be longer than the 3 years practiced in the past on the refuge, perhaps no more than every 6 or 7 years. Removal of residual cover, if needed, could be accomplished using livestock, haying, or prescribed burning. They also recommended taking periodic height-density measurements of vegetation at nest sites and random locations.

With respect to enhancing waterfowl nesting habitat, livestock grazing, prescribed burning, or haying would only be necessary if accumulation of fallen vegetation is adversely impacting new growth of vegetation and reducing the quality of duck nesting habitat. Available information suggests that reducing accumulations of dead plant material to rejuvenate waterfowl nesting habitat on Stillwater NWR/WMA and Fallon NWR would not be necessary more than once every 6-7 years. At present, well-irrigated saltgrass communities appear to be the only habitat where dead plant material would accumulate to the point where it would reduce the quality of duck nesting habitat in the Stillwater area. Whether or not herbaceous vegetation should be reduced in a particular area would depend on objectives of the area. Available information indicates that frequent grazing by livestock (every 1-3 years regardless of season of use) would adversely impact duck nesting habitat.

A potential benefit of livestock grazing along shorelines and in meadows is “Closely grazed areas of clover and grasses [on Stillwater WMA] which exposes new growth are eagerly pastured by geese during the fall and spring seasons... (Rouse 1955:3).” Rouse continued by stating that new growth will not be used if it is protected by rank vegetation. Greenwalt (1978, as cited by Strassman 1987) reported that cattle grazing can increase the abundance of edible green shoots in goose feeding areas. USFWS (1992d) cited another example in which moderate livestock grazing was used to create feeding habitat for wintering waterfowl.

Riparian Birds

Livestock grazing has generally been shown to adversely affect riparian bird species richness and abundance, resulting from loss of foraging and nesting cover, direct disturbance of low nesting birds, soil compaction, lowering of water tables, and depletion of mature stands of shrubs and trees by long-term attrition (Mosconi and Hutto 1981, Bull and Skovlin 1982, Taylor 1986, Taylor and Littlefield 1986). As explained by Knopf (1996), livestock grazing can have major, relatively immediate impacts on shrub and ground vegetation layers, whereas impacts to birds nesting in tree canopies, if they result from livestock grazing, are not immediate. However, Knopf did not address the immediate impacts of canopy nesters that also require shrub and ground cover. Populations of species dependent on tall grasses to conceal their nests decline locally while the densities and numbers of birds that favor shorter herbaceous vegetation and as livestock grazing pressure increases (Knopf 1996). Knopf also noted that, in addition to affecting vertical structure of vegetation, livestock grazing can also change the horizontal pattern of vegetation layers by creating more open shrub stands (Knopf et al. 1988, as cited by Knopf 1996).

Sanders and Edge (1998) reported significant differences in the abundance of bird species among different structural stages of willow communities in eastern Oregon. Total abundance of birds was highest in continuous riparian shrub associations, as compared to discontinuous and herbaceous xeric shrub associations. In a riparian meadow habitat in southeastern Oregon, Dobkin et al. (1998) reported marked differences between bird communities in a nearly recovered wet meadow community (characterized as a “dense, sedge-dominated community”) and nearby degraded portions of the meadow (sparsely vegetated with minor sedge component and high density of xeric shrubs). The nearly recovered wet meadow community had been rested from livestock grazing for 30 years and other parts, above and below, had been grazed up until the initiation of the study.

Ryder (1980, as cited by Knopf 1996) pointed out that species such as mountain plovers and horned larks increase and species such as meadow larks decline in response to increasing intensities of livestock grazing pressure on the Great Plains (only listed here were those species found in the Stillwater area). However, a species that increases in one local due to heavy livestock grazing may respond differently in a different location; the effect of livestock grazing on any given species depends on the effects that grazing has on its habitat. Whereas American robins and northern flickers were found to be more abundant in riparian areas being grazed by cattle in Montana and Colorado (Mosconi and Hutto 1982, Schultz and Leininger 1991, as cited by Knopf 1996), these species decline in response to livestock grazing when aspen are unable to regenerate due to grazing.

Knopf (1996) argued that the season of livestock grazing is a more important consideration than intensity of grazing. He cited several examples whereby the effects of livestock grazing were reduced by delaying grazing to late in the growing season or when vegetation was dormant. Grazing when the vegetation is dormant apparently has less impacts on bird communities because it has less impacts to the vegetation. Regardless, however, low residual herbaceous cover lasting the remainder of the year into the following nesting season would affect the diversity of ground-dwelling and nesting birds associated with dense herbaceous vegetation based on other studies cited by Knopf (1996) and others. Two of the studies cited by Knopf (1996), Sedgewick and Knopf (1987) and Knopft et al. (1988), reported no significant difference between late-season grazed and ungrazed areas in terms of population parameters of common, widespread species of birds associated with riparian habitat. Care should be taken in interpreting these results, as the conclusions of these studies only demonstrated that adverse impacts were not detected with respect to the parameters measured, as opposed to demonstrating that there were no impacts at all.

Although riparian areas have the potential to support the most diverse communities of birds on the Stillwater area, the species composition and population numbers of these riparian bird communities typify heavily disturbed, rather than healthy, riparian habitats of the Lahontan Valley. For instance, only a relatively small number of common, widespread species (e.g., American robin, red-winged blackbird, and house wrens) typically are found along the Carson River within the Stillwater WMA and Fallon NWR. Conversely, species requiring gallery stands of mature cottonwoods (e.g., yellow-billed cuckoo) and dense undergrowth or canopy of riparian shrubs (e.g., yellow-breasted chat) are rare or absent (Robert Flores, U.S. Fish and Wildl. Serv., pers. comm., 1998). On the lower Truckee River, about 50 miles away, species requiring dense understory of woody riparian vegetation that were common or abundant in 1868 were less common or absent in similar counts made in 1972, 1975, 1976, 1980, and 1981 (Klebenow and Oakleaf 1984). According to the authors of the study, "Shrub and thicket inhabitants that were completely missing from the recent surveys included the Yellow-billed cuckoo, Black-chinned hummingbird, Willow flycatcher, and Yellow-breasted chat (Klebenow and Oakleaf 1984:207). Whereas conversion to farmland and river-channel alterations were likely the major factors that adversely impacted riparian vegetation, severe livestock grazing was reported as a contributing factor.

Similarly, the dominant factor causing the degradation of the lower Carson River and Stillwater Slough is the significantly altered hydrology. However, season-long, heavy cattle grazing appears to be a contributing factor. Continued cattle grazing along the lower river would hamper restoration of the riparian habitat by limiting recruitment of cottonwoods and willows, impairing recovery of graminoids, maintaining low height of herbaceous vegetation, contributing to increased composition of invasive plant species, and trampling streambanks, as discussed previously.

Small Mammals of Riparian Areas and Meadows

Studies indicate that small mammal composition and abundance is influenced not only by the amount of riparian habitat (Brown 1978), but also by the height and density of cover resources within and among riparian and emergent wetlands (Cornely et al. 1983, Schulz and Leninger 1991). Reduction in height and density of herbaceous vegetation reduces diversity of small mammals in riparian and emergent wetlands (Kauffman et al. 1982, Medin and Clary 1989, 1990). Based on published impacts to small mammal populations, Bouffard (199?) concluded that livestock grazing can adversely impact raptors that feed on small mammals.

In the Lahontan Valley, riparian, shoreline, and meadows are the primary habitat of several small mammals species including vagrant shrew, western jumping mouse, montane vole, long-tailed vole, valley pocket gopher (Charlet, et al. 1997). Whereas shrews, jumping mice, and voles are sensitive to reduction of cover height and density, other species like pocket gophers are tolerant of reduction in cover height and density (Hanley and Page 1981, Cornely et al. 1983, Kauffman et al. 1982, Jenkins and Eshelman 1984, Maser et al. 1984b, Medin and Clary 1989, 1990, Schulz and Leninger 1991). However, all species are adversely affected by land-use practices that reduce the area composed of wetland habitat, which can result from improper road design, mismanagement of livestock, and other factors (Winegar 1977, Gebhardt et al. 1989, Kovalchik and Elmore 1992, Leonard et al. 1992). Charlet et al. (1997) surmised that maintenance, and more so the recovery of the riparian corridor in Stillwater WMA would be needed to enhance the continued existence of desert woodrat population and could potentially attract bushy-tailed woodrats. In addition to sagebrush, tall grass was listed as an important factor for maintaining healthy woodrat populations.

Using the computerized California Wildlife Habitat Relationships (WHR) database, Kie and Loft (1990) predicted the effects of livestock grazing on vertebrate wildlife species in two structural conditions (short-herb and tall-herb) for annual grassland habitat and for wet meadow habitat. They assumed that the arbitrary height category of less than 12 inches (short-herb) to be characteristic of a grazed area and greater than 12 inches (tall-herb) to be characteristic of a non-grazed area for each of the two habitats. The database predicted that reduced herbaceous height to less than 12 inches (from a height of greater than 12 inches) would positively affect 52 species, neutrally affect 171 species, and negatively affect 19 species in California annual grassland communities. In California wet meadow communities, the database predicted that reducing herbaceous height to less than 12 inches would positively affect 59 species, negatively affect 37 species, and have no effect on 169 species. Kie and Loft (1990) warned that their results should only be used as a first approximation, and that the outputs require close scrutiny for potential errors. The authors pointed out where the database listed two small mammals (montane vole and western harvest mouse) as being positively affected by reduced vegetation height, when they actually would be adversely affected by most livestock grazing systems.

Natural Operation of Biotic Processes

The variety of biotic processes is a component of biological diversity (Noss 1990, DeLong 1996, U.S. Fish and Wildl. Serv. 1996). Some of the biotic process operating in riparian, shoreline, and meadow areas are herbivory, succession, predation, immigration, and emigration of species.

Although herbivory is a natural ecological process in the Stillwater area, as it is in all ecosystems containing vegetation, the process of herbivory by livestock does not necessarily mimic natural herbivory rates. Possibly the only ungulate to occupy the Stillwater area in any numbers or with any regularity is the mule deer, although bighorn sheep and pronghorn occasionally wandered through the area, as possibly did an occasional elk or bison. Mule deer likely inhabited the riparian corridors associated with the Carson River and its abandoned channels. Other herbivors in riparian corridors and floodplain meadows likely included mountain cottontails, montane voles, other rodents, and a large variety of insects and other invertebrates. Although no references were found, several species of invertebrates would have grazed vegetation in the Carson River. As with most other areas throughout the Intermountain West (Miller et al. 1994), the introduction of livestock in the mid and late 1800s brought with it a significant increase in grazing and browsing pressure on plant communities throughout this area. I am unaware of any information suggesting that natural herbivory rates by mule deer, cottontails, voles, and other native herbivores would not occur given sufficient recovery of riparian and other habitats and response by these species.

Livestock herbivory can speed or slow vegetative succession, depending on the plant community, its current seral stage, among other factors (Gifford 1976, Archer and Smeins 1991, Pieper 1994). It can also affect the direction of succession (Kovalchik and Elmore 1991). For example, to the extent that livestock herbivory pressure inhibits recruitment of cottonwoods, willows, and other native riparian woody vegetation, it slows succession and may result in succession proceeding toward a more xeric shrub community or saltcedar community rather than a mature stand of native riparian woody vegetation. Similarly, heavy to severe livestock grazing on Stillwater WMA (Rouse 1955, Wiseman 1962), likely has contributed to meadow communities succeeding toward mature stands of non-native mesic woody vegetation (e.g., saltcedar) in areas not naturally supporting woody vegetation. The significant alterations in Carson Desert wetland hydrology (Kerley et al. 1993) is likely a more important factor contributing to more xeric conditions in riparian zones in the Stillwater area.

As noted elsewhere in this report, livestock grazing can affect predation rates by altering vegetative structure making nests more vulnerable to predators. It is also possible that the presence of livestock grazing operations in the area may have increased survival and abundance of black-billed magpies and common ravens by providing winter forage for these birds (i.e., unrecovered livestock carcasses). Thus, livestock grazing may contribute to higher nest depredation rates in several ways. Conversely, livestock grazing operations in the area may maintain lower populations of coyotes.

Introduction and continuation of livestock grazing in the Intermountain West has contributed to the introduction and spread of noxious weeds (Lacey 1987), both by depositing weed seeds in areas away from where they were ingested and by enhancing germination and growth of less palatable weeds (i.e., by lowering competiveness of native vegetation).

Broad-leaved Weeds

Non-native, broad-leaved forbs (broad-leaved weeds) is an ongoing and likely increasing threat to some refuge habitats. Livestock contribute to the introduction and spread of noxious weeds (Lacey 1987) and possibly saltcedar (pers. obs.).

Measures must be taken to eliminate (where possible) or control broad-leaved weeds. Use of livestock to control broad-leaved weeds has been shown to be effective under a variety of circumstances, and not-so-effective under other circumstances (Parman 1986, Lacey 1987, Brock 1988). In general, sheep seem to hold the most promise for controlling broad-leaved weeds (Lacey 1987, Brock 1988) and cattle apparently hold the least promise (Brock

1988). Another potential advantage in using sheep in noxious-weed control efforts is that, compared to cattle grazing, sheep grazing appears to have fewer impacts to riparian areas (Glimp and Swanson 1994).

Most references to control of weeds by livestock refer to the use of goats and sheep (Lacey 1987, Brock 1988, USBLM 1991:3-13). Lacey (1987) explained that, to be effective, the grazing animal must be adapted to using weedy plants (in our case, broad-leaved weeds). Evolutionary adaptations of different classes of livestock (e.g., cattle, sheep, goats) predisposition them to feed on particular food groups (e.g., grasses, forbs, browse)(Hanley 1982; Provenza and Balph 1987 as cited by Stuth 1991). Sheep primarily feed on forbs, and browse and grass to a lesser extent; goats primarily feed on browse, but they use all classes of forage; and cattle primarily feed on grass (Brock 1988). Cattle generally prefer eating grass in contrast to forbs (Hanley and Hanley 1982, Brock 1988, Stuth 1991). The small mouth of sheep, along with their small body size and relatively large rumen allow them to be selective feeders (Hanley 1982 for review). The rumen of cattle is large, allowing them to subsist on high cellulose forage (e.g., grass).

Dalrymple (1991) points out economic benefits of using livestock to control weeds compared to mechanical and herbicide treatments. Economic savings, however, assume that livestock (e.g., sheep or goats for controlling broad-leaved weeds) are readily available or grazing systems can merely be adjusted to control weeds in particular areas.

Brock (1988) provides two examples where cattle successfully had been used to control particular plant species: (1) cattle effectively controlled aspen suckering, and (2) cattle controlled leafy spurge through repeated trampling. The second example was based on an observation (not a study) made by Gene Foss, a rancher, as reported by Parman (1986), which Lacey (1987) pointed out has not been quantified by research. Lacey went on to discuss at length a study that documents the avoidance of leafy spurge by cattle.

Lacey (1987) provides 6 examples where cattle were used to control weeds: (1) the Parman (1986) example was discussed previously, (2) as was the study that contradicted his observation; (3) cattle effectively controlled aspen suckering (same reference used in Brock 1988); (4) cattle were not effective at decreasing the cover of clubmoss (<u>Selaginella</u> <u>densa</u>); (5) cattle have been reported to used prickly pear (<u>Opuntia</u> <u>polycantha</u>) after spines have been burned off (however, no mention was made in regard to control of prickly pear); (6) cattle were not effective in attempts to control spotted knapweed (<u>Centaurea</u> <u>maculosa</u>).

Advantages in using livestock for controlling noxious weeds, according to USBLM (1991:1-22), are: "(1) they use weeds as a food source, (2) following a brief adjustment period, they sometimes consume as much as 50 percent of their daily diet of this species, (3) average daily gains of offspring grazing certain weed-infested pastures can sometimes be significantly higher than average daily gains of offspring grazing grass pastures, and (4) sheep or goats can be used in combination with herbicides." As pointed out in USBLM (1991), these advantages mainly apply to sheep and goats. Disadvantages of using domestic animals (e.g., cattle, sheep, goats) are: "(1) they also use nontarget plants as food sources, (2) the use of domestic animals, like sheep or goats, require a herder or temporary fencing, (3) the animals may be killed by predators such as coyotes, (4) heavy grazing of some weed species, such as leafy spurge, tends to loosen the stool of the grazing animals, and (5) most weed species are less palatable than desirable vegetation and would cause overgrazing" (USBLM 1991). The dangers of the spread of weeds by livestock were discussed at length by Lacey (1987). He recommended that livestock that previously had grazed in areas infested by weeds be confined for 9-10 days before being introduced into weed-free areas. According to Lacey, cattle are major dispersers of weed seeds in some areas.

Based on the information presented above, cattle would likely have limited value for controlling broad-leaved weeds on the Stillwater and Fallon NWRs. Lacey (1987) pointed out that the effects of grazing on weed populations has not been satisfactorily evaluated in research trials, and that extensive trial and error is needed to implement a selective grazing program. He also pointed out that "the feasibility of controlling range weeds with the application of extensive livestock management practices is limited," although further research is warranted.

<u>Management Implications: Riverine-riparian, Marsh Shoreline, and Meadow</u>

Continued livestock grazing in these areas could hinder recovery of riparian functioning and native riparian plant communities, and would hinder the approximation of the natural composition and structure of plant communities in riparian, shoreline, and meadow areas, thus hampering the restoration of the natural diversity of wildlife in these habitats.

Given the vast acreage of periodically-flooded low-statured vegetation in the Lahontan Valley --- e.g., flooded pasture (grazed by livestock), flooded alfalfa (mowed and grazed), grazed shoreline (e.g., Harmon Reservoir, Carson Lake) — and the near absence of perennial meadow habitat in the valley, there is little need to produce additional low-statured meadow and shoreline habitat. Under natural conditions in Lahontan Valley, there would be several thousand acres of flood-plain meadow habitat, characterized in part by residual vegetation carrying over year-to-year. This contrasts with existing conditions in the Lahontan Valley where very little if any comparable habitat exists today and more than 50,000 acres of periodically-flooded low-statured vegetation. There may be small patches and short, narrow strips of vegetation of similar structure, but given their diminutive size and disconnectedness, they do not function as flood-plain habitat. Viewing the Lahontan Valley as a whole (and even the western Great Basin or the entire Intermountain West), management of meadow and similar habitats to approximate natural meadow composition and structure would appear to best contribute toward the restoration of natural biological diversity. This would likely require the complete exclusion or significant reduction in livestock grazing in riparian areas, meadows, and shorelines in the project area, except when specifically needed to control noxious weeds, in which case goats or sheep would be a preferred class of livestock.

Cattle could potentially be used to reduce or trample accumulations of dead-plant material when it is so dense that it insulates the soil and blocks light penetration (thereby inhibiting new growth) and when this would not conflict significantly with restoring and maintaining natural biological diversity (with respect to Stillwater NWR). This application, which focuses on rejuvenating waterfowl nesting habitat, would likely not have to be done more than once every 6 or more years. Furthermore, prescribed burning may be a more effective technique.

In summary, information indicates that goats and sheep can be effective as part of an integrated weed management program to control certain types of noxious weeds. It also indicates that cattle grazing would be ineffective in controlling noxious weeds.

Marsh

The use of cattle to create openings in emergent vegetation in wetland units of Stillwater Marsh has been discussed in several refuge reports. In the introduction to his *Range Survey Report*, Rouse (1955:3-4) stated that “The grazing of livestock in the marsh area is also an important factor in developing and maintaining the marsh in a condition attractive to waterfowl. The strip of open water along the shore which is developed and maintained by grazing livestock has been demonstrated to increase the value of the marsh for certain species of nesting ducks. In the absence of grazing by livestock, the marsh tends to fill in to the shore line in a solid stand of vegetation... Spring grazing which will make use of the succulent new growth of emergent vegetation, such as cattail and hardstem bulrush as it appears, helps to maintain the margin of open water along the shoreline and also helps to prevent the stand of vegetation from becoming too dense in the shallower parts of the marsh.” In a 2-year study of the habitat relationships of nesting ducks, Marshall (1952:14) found that “With but several exceptions did a pair of puddle ducks locate on a pond that was completely separated from land or a dike by heavy emergent growth. Puddle duck territory required some dry land (open-shore edge) adjoining open water or low, thin emergent growth...” and that “No territories [of any species of duck] were established in heavy emergent growth such as cattail or hardstem bulrush...”

The of use of cattle to open up stands of emergent vegetation has also been reference in the published literature. In his review of literature, Kantrud (1990) described the benefits of creating openings in tall, dense emergent vegetation in marshes of the prairie pothole region by using prescribed burning and/or livestock grazing. Kantrud's (1990) paper focused on the problem of excessively dense and tall emergent wetland vegetation. Holechek et al. (1995:357) generally stated that livestock can be selectively grazed to open up dense stands of vegetation.

Whereas overly-dense tall emergent vegetation in Stillwater Marsh was reported as a problem in the early 1950s (Marshall 1952), it is not a problem at present. Part of this is due to the relative low occurrance of extensive stands of emergent vegetation at present, compared to conditions of the early 1950s. It is also a consequence of a shift in management direction that now calls for restoration of natural features of Stillwater Marsh. One consideration with respect to natural features of the marsh as it relates to livestock grazing is the existence of extensive stands of dense emergent vegetation that occurred during some periods (Gov. Land Office maps, 1868, 1882; Refuge files). Although seasonal flooding likely matted down stands of emergent vegetation, this would have occurred primarily along the main courses of water where flow rate was highest (i.e., deep-water areas). The impact of this disturbance would have lessened toward shorelines. Conversely, without controls, livestock tend to graze along shorelines and shallow-water areas first, before moving further into the marsh.

Benefits of creating openings in emergent stands primarily pertain to use of marshes by breeding pairs of waterfowl and their broods during breeding season (Kantrud 1990); discussion relative to nesting habitat was limited. Although Kantrud cited a number of sources that provide evidence that heavy grazing use — enough to create openings in marsh vegetation — can benefit some species of waterfowl, he also cited several others that reported on the adverse impacts of heavy to severe grazing of marsh vegetation and vegetation along shoreline areas. In a Stillwater WMA pond rimmed by baltic rush, cattle grazing appears to have limited or reduced the width of emergent vegetation band (observ. of the author based on cone exclosures).

Just as cattle can be used to create openings in dense emergent vegetation, they can also be used in some situations to create and sustain low-statured vegetation over expansive areas of shallow wetlands where the potential plant community would be dominated by emergents. This can be accomplished by heavy grazing or trampling or by altering vegetation composition away from emergents through the same processes. Cattle are used on Carson Lake (managed jointly by the Nevada Division of Wildlife and Truckee-Carson Irrigation District), with apparent success, to maintain low vegetation height in seasonally-flooded pastures and shallow wetlands for waterfowl and shorebird feeding habitat (L. Neel and N. Saake, Nevada Div. of Wildl., Fallon, pers. comm. 1995). Excessive livestock grazing in emergent wetlands can reduce plant vigor (Taylor 1986, Clary and Webster 1989, Platts 1989), and reduced vigor of particular species can result in changes in composition of wetland plant communities (Hargis and McCarthy 1986, Young 1986, Kovalchik 1987, Kovalchik and Elmore 1992).

Heavy grazing by cattle was used in Washington to alter shoreline vegetation composition from emergents toward annual grasses used by waterfowl broods (Harris 1954, as cited by Bundy 1993). Cattle grazing can be used to reduce dense emergent vegetation to provide germination sites for annual producers (Kantrud 1986 and Chabrek et al. 1989, as cited by Bundy 1993). In these cases, grazing of emergent vegetation is not as important as trampling of the vegetation (Kantrud 1986, as cited by Bundy). Whereas there appear to be benefits of using cattle to shift vegetation composition from emergents toward annual plants in some cases, depending on objectives, livestock grazing can also deplete annual vegetation. This can be beneficial or detrimental, depending on objectives for the area. For example, Rouse (1955:29) noted that "The greater part of the palatable herbaceous forage [eaten by cattle using Stillwater Marsh] is provided by alkali weed and Russian thistle and similar annuals which are heavy seed producers..." To the extent that non-native annual vegetation is depleted, this would tend to enhance the native diversity of plant communities. Conversely, grazing of these seed-producing annual plants during the growing season would not enhance their productivity and would likely serve only to reduce the quantity of seeds produced, thus lowering the potential benefits to waterfowl later in the year (assuming sufficient water is available to flood these areas in the fall and winter). Rouse (1955) also noted correctly that alkali weed, Russian thistle, and similar annual plants "come up abundantly in response to water and with little regard to previous grazing use." However, this does not discount the reduction in seed production in the same year that livestock grazing takes place. It also brings to question the viability of using livestock to control non-native annuals where this is desired, recognizing nontheless, that there may not be a more suitable alternative.

In addition to maintaining the low-vegetation structure preferred by some species of birds, it is also speculated that livestock grazing in marshes can increase invertebrate abundance (Kantrud 1990), which would also appear to apply to flooded pastures and meadows. However, few if any studies have examined this hypothesis. Bundy (1993) cited two studies (Whyte and Cain 1981, Whyte et al. 1981) proposing that light, controlled grazing by livestock can be used to reduce perennial stands of emergent vegetation to promote seed and invertebrate production for brood and winter habitat. However, "light" use of any given stand of emergent vegetation would likely not measurably alter plant-community structure. More likely, heavy grazing pressure would be needed in areas dominated by emergent vegetation as suggested by Marshall (1951) for this purpose.

Natural Operation of Biotic Processes

Much of the discussion under the Riverine-riparian, Marsh Shoreline, and Meadow section applies here as well. Native herbivores in emergent and submergent marshes include muskrats, coots, a great variety of waterfowl such as tundra swans, gadwall, and mallards, and many species of invertebrates grazed emergent and submergent vegetation. Aside from creating openings in dense emergent vegetation, as muskrats do, livestock likely do not approximate herbivory by these species.

Management Implications: Marshes

Cattle can be used to create openings in emergent vegetation if they don't have ready access to more favored forage or if densities are high enough to result in trampling of the vegetation. However, on Stillwater NWR, consideration must be given to the restoration of natural biological diversity, with which this application could conflict. This application of livestock would enhance nesting and brooding habitat of some species of waterfowl and other waterbirds. However, if not strictly controlled, using livestock to create openings in dense emergent vegetation could result in heavy to severe grazing on nearby shorelines and reduction of nesting habitat for species dependent on such dense vegetation.

Uplands

By reducing the amount and height of residual herbaceous cover in uplands, cattle grazing can effect wildlife species that depend on this component of the environment. Rouse (1955) believed that early spring use by livestock in upland areas was responsible for the disappearance of Indian ricegrass, a keystone species in plant communities in which it occurs. He recommended that spring turn-out be delayed until May 15 to reduce adverse impacts to upland plants.

In general, livestock grazing can advance the rate of succession from a grass-dominated to a shrub-dominated state where perennial grasses and forbs are grazed frequently and intensively during the growing season (Ellison 1960, Tisdale and Hironaka 1981, Blaisdell et al. 1982, Monsen and McArthur 1985, Winward 1985). No published information was found on the effects of livestock grazing on shrub cover in salt desert shrub communities. However, such information does exist for sagebrush communities, which occur at slightly higher elevations than the salt desert shrub communities of the Stillwater area. Cover of herbaceous plants has been found to inversely relate to cover of sagebrush beyond a threshold level (e.g., >15% cover of Wyoming big sagebrush) that differs with site potential (Sneva et al. 1984, Winward 1991, Laycock 1991). In the intermountain west, increase in cover of sagebrush and other shrubs is associated primarily with frequent, intensive use of herbaceous plants during the growing season coupled with fire exclusion (Ellison 1960, Laycock 1967, Blaisdell et al. 1982, Heady 1983, Kauffman 1990). To the extent that livestock grazing has reduced the cover and abundance of perennial bunch grasses and other herbaceous vegetation in salt desert shrub communities, shrub cover may have increased in response.

Livestock grazing appears to have had a major effect on condition of some upland plant communities in the Stillwater area (Rouse 1955, Wiseman 1962, Charlet 1997). Ecological communities in the northern Great Basin were affected by herbivorous hoofed mammals only to a limited degree prior to introduction of domestic livestock (Young et al. 1976, Mack and Thompson 1982, Miller et al. 1994), especially in salt desert shrub communities in which production of herbaceous vegetation was comparatively low. Collectively, bunchgrasses are less resistant to frequent grazing, especially during growing season, compared to sod-forming grasses characteristic of the Great Plains (Blaisdell et al. 1982, Mack and Thompson 1982).

Much has been written about the benefits of livestock grazing in upland areas of the Western United States. However, although the removal of standing dead plant material on a periodic basis is considered beneficial to plant health by some authors (Savory 1988, Anderson 1993), standing dead plant material has been shown to be beneficial to plant health by others (Sauer 1978, Sneva 1980, Briske 1991). Others have found neutral effects of removing dead plant material during the dormant season (Britton et al. 1990). Furthermore, no studies were located that identified any vegetation benefits associated with livestock grazing in upland areas receiving less than 6 inches of precipitation per year on average. Holecheck et al. (1995:129) pointed out that positive effects of controlled livestock grazing would most likely occur in areas receiving at least 16 inches of precipitation per year on average.

They surmised that excessive accumulations of dead plant material generally does not occur due to aridity. With respect to benefits to wildlife, they asserted that benefits of controlled grazing generally would not occur in areas receiving less than 20 inches of precipitation per year (Holechek et al. 1995:357).

The discussion in the preceding paragraph does not fully address the ecological perspective of restoring natural biological diversity. From this standpoint, benefits to individual plants are of secondary importance to the natural composition and structure of vegetation. Even if livestock grazing were to increase plant vigor, this could diminish natural vegetative diversity in the area. Given the limited grazing pressure on native bunchgrasses in the Carson Desert and slow decomposition rates, accumulations of dead plant material was only one component of the habitat in which they evolved.

Two potential benefits of cattle grazing have been identified specific to the Stillwater area: (1) pushing existing Indian ricegrass seeds below the soil surface through hoof action (R. Mills, Fallon, Nevada, pers. comm. 1995), and (2) removing cheatgrass residues after the growing season to reduce fire potential (W. Longland, Agric. Res. Serv., Reno, Nevada, pers. comm., 1997). Specifically regarding the actual placement of seeds and their germination, the first hypothesis seems plausible given the germination requirements of Indian ricegrass. In describing planting methods for revegetating disturbed lands, Wasser (1982) recommended drilling seeds 1-1/2 to 3 inches deep in medium course-textured soils, noting that seeds emerge well from 4 inches in sand, although Young et al. (1994) found that seedlings emerged best from depths of 6 inches, as compared to shallower depths. These deep planting depths stem from the symbiotic relationship that has formed between Indian ricegrass and kangaroo rats, which bury Indian ricegrass seeds in caches (Longland 1992). Although it seems likely that cattle can trample Indian ricegrass seeds deeper into soils, thus enhancing germination, the benefits of this approach on Stillwater NWR or Fallon NWR would seem to be outweighed by the adverse impacts of cattle grazing. Areas supporting Indian ricegrass also have populations of kangaroo rats, and wind-blown sand also acts to bury Indian ricegrass seeds. As Indian ricegrass populations are permitted to increase, kangaroo rat populations would likely expand as well, thus increasing the potential for further expansion of Indian ricegrass stands. One method to supplement Indian ricegrass stands would be to provide seed to kangaroo rats and other rodents in feeding devices or to broadcast seed in areas occupied by these rodents (Barrow and Havstad 1992).

To the extent that cattle would forage on standing dead cheatgrass during the late summer after the growing season and before the highest potential for fire, they could be effective in reducing the potential for ignited fires to spread. However, to be effective, this would have to be done every year over large areas. Furthermore, because other green forage (e.g., greasewood and other shrubs) and other palatable vegetation (e.g., dormant Indian ricegrass plants) would be available during the late summer, cattle would not limit their foraging to standing, dead cheatgrass.

Natural Operation of Biotic Processes

Large ungulates that would use the Lahontan Valley under natural conditions include mule deer (existing today), and occasional pronghorn (rare occurrences today), bighorn sheep (non-existent today), and possibly an occasional elk or bison (non-existent today). These species may have grazed or browsed in uplands, but this likely would not have been extensive given the low production of these lands. However, black-tailed jackrabbits, white-tail antelope ground squirrel, Merriam kangaroo rats, and a large number of invertebrates grazed and browsed in upland habitats.

Control of location, timing, and intensity of livestock use determines which foods are selectively used by livestock and whether livestock-use significantly influences plant succession (Ellison 1960, Blaisdell et al. 1982, Blaisdell and Holmgren 1984, Platts and Nelson 1985). Because large ungulates are not a natural component of salt desert shrub or dune ecosystems, the potential is high for cattle to interfere with natural successional patterns.

Control of Cheatgrass and Enhancement of Native Perennial Grasses and Forbs

Livestock grazing has been examined as a means to control cheatgrass at least as far back as the 1940's (Vallentine and Stevens 1992). Livestock grazing also is generally considered a factor in promoting the establishment and prominence of cheatgrass (Vallentine and Stevens 1992). The concept of using cattle to control cheatgrass and enhance native perennial grasses was described by Krueger and Buckhouse (1993) as follows. Cattle grazing conducted early in the spring, when cheatgrass is rapidly growing and native bunchgrasses have not yet begun to grow would adversely impact cheatgrass while having minimal impacts on native bunchgrasses. If cattle are removed while adequate soil moisture remains, bunchgrasses would complete their development. Under this treatment, cheatgrass would decline in abundance and native perennial bunchgrasses would increase in cover. This conceptual framework is consistent with that provided by Vallentine and Stevens (1992). They cite several studies that demonstrate that clipping and grazing by livestock can hinder the growth of, or kill, cheatgrass.

There does not appear to be any studies, however, that demonstrate that cheatgrass growth can be hindered without impacting native perennial bunchgrasses. Vallentine and Stevens (1992) reason that sufficient information probably does not exist to carry out the precise control over cattle grazing that would be required to effectively control cheatgrass within a narrow window of opportunity that may exist. J. Young (Agric. Res. Serv., Reno, Nevada, pers. comm., 1993) noted that many times native bunchgrasses are emerging prior to emergence of cheatgrass. Tisdale and Hironaka (1981) found that native perennial grasses were more adversely impacted than cheatgrass following simultaneous clipping.

Valentine and Stevens (1992) concluded that livestock grazing is not an effective method of controlling cheatgrass. Sanders (1992), in assessing its practicality, found that the preponderant evidence indicates little chance of conversion from annual to perennial grassland communities through grazing management in areas receiving less than 12 inches of precipitation per year. The Stillwater area receives an average of less than 5 inches of precipitation per year (Dollarhide 1975).

Management Implications: Uplands

Livestock grazing does not appear to be an appropriate method for restoring and sustaining healthy uplands and natural biological diversity in uplands. Few applications of livestock grazing were identified that would apply to the upland areas in the project area. I am unaware of any information suggesting that natural herbivory rates would not occur, or are not occurring, on the refuges given sufficient recovery of habitats and subsequent response by native herbivores. In cases where the purpose of a particular application was consistent with refuge goals and purposes (e.g., controlling cheatgrass), available information indicates that livestock would be ineffective for the purpose at hand.

Farmland

Cattle grazing can increase the abundance of edible green shoots in goose feeding areas (Greenwalt 1978, as cited by Strassman 1987). USFWS (1992d) cited another example in which moderate livestock grazing was used to create feeding habitat for wintering waterfowl.

Cattle are used in the Lahontan Valley to maintain low cover of weeds (along with the planted crop) until the growing season of the desired crop (Bill Henry, U.S. Fish and Wildl. Serv., pers. comm., 1998). In cases where farmers produce crops on refuge lands (agricultural fields west of Hunter Road and south of the Canvasback Gun Club), cattle would appear to be an appropriate way to impede growth of plants until the growing season of the planted crop.

In farmland areas, adverse impacts to native plant communities obviously is not a major concern. Thus, options for using cattle for the purposes described above are not limited to any large extent by environmental concerns.

SCIENTIFIC RESEARCH, ENVIRONMENTAL EDUCATION, AND WILDLIFE-ORIENTED RECREATION

Public Law 101-618 requires that opportunities for scientific research, environmental education, and wildlife-oriented recreation be provided on Stillwater NWR. The Nevada Chapter of The Wildlife Society identified a need in Nevada to set aside large areas as ungrazed, control areas to study the impacts of livestock grazing (Nevada Chapt. of The Wildl. Soc. 1995).

With respect to environmental education and wildlife-oriented recreation, the NWRS Administration Act, as amended, directs the Service to facilitate wildlife-dependent recreation (including environmental education and interpretation) to the extent that it is compatible with refuge purposes and the Refuge System mission. One of the principles outlined in Executive Order 12996 is that opportunities for wildlife-dependent recreation can only be provided to the extent that high quality habitat exists to provide for the needs of wildlife. Thus, livestock grazing can affect the Service's ability to meet public-use management mandates by negatively and positively affecting wildlife and wildlife habitat. These effects comprise the bulk of this report.

Livestock grazing can affect recreation experiences by influencing where people choose to view wildlife. According to public comment, the presence of cattle can have a negative impact on visitors' experiences. Riparian areas and marshes are popular places for birdwatching and viewing other types of wildlife viewing, and cattle in these areas may disturb these wildlife enthusiasts. Fences on the Refuge may hinder recreation experiences for those seeking a natural appearing environment.

CULTURAL RESOURCES

Livestock grazing can increase the chance of surface artifacts and exposed burials being trampled. Because heavy and severe livestock grazing can expose soil surface, it can also expose artifacts which would otherwise by covered with vegetation, thus increasing the possibility of theft.

CONCLUSIONS

After evaluating the effects of the existing livestock grazing program of season-long use and potential applications of livestock grazing as a management tool, several applications of livestock grazing that could potentially be used to help accomplish the goals of Stillwater NWR and Fallon NWR were idenified in this report. They are:

- the use of sheep and goats as part of an integrated pest management plan to control noxious weeds;
- the use of cattle to control weeds in farm fields and along associated irrigation ditches;
- the use of cattle to enhance vegetation in farm fields for Canada geese and other waterfowl;
- the use of cattle to create openings in dense stands of emergent vegetation, recognizing that extensive stands of dense emergent vegetation are part of the natural marsh ecosystem; and
- possibly the periodic (once every 6-7 years or more) use of cattle to reduce accumulations of dead plant material in meadows, irrigated pastures, and along shorelines to rejuvenate vegetation used for nesting cover, recognizing that accumulations of dead plant material over extensive areas is a natural part of the ecosystem and a missing element of riparian and other wetland communities throughout the west.

These potential uses are generally consistent with the recommendations received from the July 1997 Habitat Management Workshop. They are further addressed in a compatibility determination addressing livestock grazing on Stillwater and Fallon NWRs.

One factor that must be considered in any livestock grazing program on a national wildlife refuges was characterized by Braun et al. (1978:311): "...when grazing is allowed [on a national wildlife refuge], the USFWS frequently loses control of local situations due to intense political pressure at all levels of administration." To the extent this is true, it can have significant effects on programs that are initially well designed with the needs of wildlife at the forefront. This ultimately means that livestock grazing should only be used on refuges if it is absolutely necessary to achieve refuge purposes and there are no other feasible management tools at the manager's disposal. Although the five applications listed above were identified as ones that could be used toward achieving draft refuge goals, none are absolutely necessary. Aside from the first listed application, none apply to the main thrust of management of Stillwater NWR, that of restoring or approximating natural habitat conditions and the health of the ecosystem.

Acknowledgments: Some of the riparian information in this report was originally written by W. Pyle for a similar report written by the author and W. Pyle for Hart Mountain National Antelope Refuge. I thank D. Walsworth, R. Flores, W. Henry, and R. Bundy for reviewing an earlier draft of this report.

LITERATURE CITED

Antevs, E. 1948. Climatic changes and pre-white man. Pages 168-191 *in* The Great Basin; with emphasis on glacial and postglacial times. Bull. Univ. Utah Biol. Ser. 10(7).

Armour, C.L. D.A. Duff, and W. Elmore. 1991. The effects of livestock grazing on riparian and stream ecosystems. Fisheries 16:7-11.

Blaisdell, J.P., R.B. Murray, and E.D. McArthur. 1982. Managing Intermountain rangelands--sagebrush-grass ranges. U.S. For. Serv. Gen. Tech. Rep. INT-134. Ogden, UT. 41pp.

Blaisdell, J.P., and R.C. Holmgren. 1984. Managing Intermountain rangelands-salt desert shrub ranges. U.S. For. Serv. Gen. Tech. Rep. INT-163. Ogden, UT. 52pp.

Bohn, C.C. and J.C. Buckhouse. 1985. Some responses of riparian soils to grazing management in northeastern Oregon. J. Range Manage. 38:378-381.

Braun, C.E., K.W. Harman, J.A. Jackson, and C.D. Littlefield. 1978. Management of National Wildlife Refuges in the United States: its impacts on birds. Conservation Comm. Rep. Wilson Bull. 90:309-321.

Britton, C.M., G.R. McPherson, and F.A. Sneva. 1990. Effects of burning and clipping on five bunchgrasses in eastern Oregon. Great Basin Naturalist 50:115-120.

Brock, J.H. 1988. Livestock: biological control in brush/weed management programs. Rangelands 10:32-34.

Brown, J.H. 1978. The theory of insular biogeography and the distribution of boreal birds and small mammals. pp. 209-228 *In* Harper, K.T., and J.L. Reveal, tech. coords. Intermountain biogeography: A symposium. Great Basin Nat. Memoirs 2, Brigham Young Univ., Provo, UT. 268pp.

Buckhouse, J.C., and W.E. Elmore. 1993. Grazing practice relationships: Predicting riparian vegetation response from stream systems. *In* Bedell. T.E., ed. Watershed management guide for the interior Northwest. EM 8436. Oregon State Univ., Corvallis, OR.

Bull, E.L., and J.M. Skovlin. 1982. Relationship between avifauna and streamside vegetation. Trans. North. Am. Wildl. and Nat. Resour. Conf. 47:.

Bundy, R.M. 1993. Livestock grazing on public lands: beneficial or detrimental to meeting wildlife habitat objectives? Unpubl. report, on file at: Stillwater National Wildlife Refuge office, Fallon, Nevada. 15pp.

Burkhardt, J.W. 1996. Herbivory in the Intermountain West: an overview of evolutionary history, historic cultural impacts, and lessons learned from the past. Stat. Bull. 58, Idaho For., Wildl., and Range Exp. Stat., Univ. of Idaho, Moscow. 35pp.

Chabrek, R.H., T. Joanen, and S.L. Paulus. 1989. Southern coastal marshes and lakes. Pgs. 249-277 *in* Smith, L.M., R.L. Pederson, and R.M. Kaminski (eds.). Habitat management for migrating and wintering waterfowl in North America. Texas Tech. Univ. Press, Lubbock.

Chaney, E., W. Elmore, and W.S. Platts. 1993. Managing change: livestock grazing on western riparian areas. U.S. Envir. Protection Agency, Denver, CO. 31pp.

Charlet, D.A., S.D. Livingston, H. Powell, R. Bamford, T. Wade, M.M. Peacock, C.R. Tracy, and M. Rahn. 1997. Floral and faunal survey of the Stillwater National Wildlife Refuge, Stillwater Wildlife Management Area, and Fallon National Wildlife Refuge: progress report to the U.S. Dept. of Inter., Fish and Wildl. Serv. Biol. Resources Res. Center, Dept. of Biol., Univ. of Nevada-Reno, Reno. 45pp.

Clary, W.P., and B.F. Webster. 1989. Managing grazing of riparian areas in the Intermountain region. U.S. For. Serv. Gen. Tech. Rep. INT-263, Ogden, UT. 11pp.

Cornely, J.E., C.M. Britton, and F.A. Sneva. 1983. Manipulation of flood meadow vegetation and observation on small mammal populations. Prarie Nat. 15:16-22.

Dalrymple, R.L. 1991. Using grazing for weed control. The Stockman Grass Farmer 48:1,8.

Davis, J. O. 1982. Bits and pieces: the last 35,000 years in the Lahontan area. Soc. Amer. Arch. Paper No. 2.

DeLong, D.C.Jr. 1996. Defining biodiversity. Wildl. Soc. Bull. 24:738-749.

Dobkin, D.S., A.C. Rich, and W.H. Pyle. 1998. Habitat and avifauna recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin. Conserv. Biol. 12:209-221.

Dollarhide, W.E. 1975. Soil survey of Fallon-Fernley area, Nevada; parts of Churchill, Lyon, Storey, and Washoe Counties. U.S. Department of Agriculture, Soil Conservation Service, Fallon, Nevada. 112pp.

Dunaway, D., S.R. Swanson, J. Wendel, and W. Clary. 1994. The effect of herbaceous plant communities and soil textures on particle erosion of alluvial streambanks. Geomorphology 9:47-56.

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman and Co., NY. 818pp.

Ellison, L. 1960. Influence of grazing on plant succession of rangelands. Botanical Rev. 26:1-78.

Elmore, W., and R.L. Beschta. 1987. Riparian areas: Perceptions in management. Rangelands 9:260-265.

Gebhardt, K.A., C. Bohn, S. Jensen, and W.S. Platts. 1989. Use of hydrology in riparian classification. pp. 53-59 *In* Gresswell, R.E., B.A. Barton, and J.L. Kershner, eds. Practical approaches to riparian resource management: An education workshop. U.S. Bur. Land Manage. BLM-MT-PT-89-001-4351, Billings, MT. 193pp.

Gilbert, D.W., D.A. Anderson, J.K. Ringleman, and M.R. Szymczak. 1996. Response of nesting ducks to habitat and management on the Monte Vista National Wildlife Refuge, Colorado. Wildl. Monogr. 131. 44pp.

Glimp, H. A. and S. R. Swanson. 1994. Sheep grazing and riparian and watershed management. Sheep Research Journal, Spec. Issue:65-71.

Gjersing, F.M. 1975. Waterfowl production in relation to rest-rotation grazing. J. Range Manage. 28:37-42.

Greenwalt, L.A. 1978. The National Wildlife Refuge System. Pages 399-412 *in* H.P. Brokaw (ed.). Wildlife and America. Council on Environmental Quality, U.S. Government Printing Office, Washington, D.C.

Hanley, T.A. and J.L. Page. 1981. Differential effects of livestock use on habitat structure and rodent populations in Great Basin communities. Calif. Fish and Game 68:160-174.

Hanley, T.A. 1982. The nutritional basis for food selection by ungulates. J. Range Manage. 35:146-151.

Hanley, T.A. and K.A. Hanley. 1982. Food resource partitioning by sympatric ungulates on Great BAsin rangelands. J. Range Manage. 35:152-158.

Hargis, C., and C. McCarthy. 1986. Vegetation changes following a prescribed burn on a Great Basin meadow. Trans. Western Section Wildl. Soc. 22:47-51.

Harris, S.W. 1954. An ecological study of the waterfowl of the potholes area, Grant County, Washington. Am. Mid. Nat. 52:403-432.

Hayes, F. A. 1978. Streambank stability and meadow conditions in relation to livestock grazing in mountain meadows of central Idaho. M.S. Thesis, Univ. Idaho. 91pp.

Heady, H.F. 1983. Succession and climax in the sagebrush-grass type. pp. 13-18 *In* Symposium on livestock and wildlife-fisheries relationships in the Great Basin. Univ. California, Berkeley, CA. 173pp.

Heede, B.H. 1966. Design, construction and cost of rock check dams. U.S. For. Serv. Res. Paper RM-20, Fort Collins, CO. 24pp.

Holechek, J.L., R. Valdez, S.D. Schemnitz, R.D. Pieper, and C.A. Davis. 1982. Manipulation of grazing to improve or maintain wildlife habitat. Wildl. Soc. Bull. 10:204-210.

Holechek, J.L., R.D. Pieper, and C.H. Herbel. 1989. Range management. Prentice-Hall, Inc., New Jersey. 501pp.

Holechek, J.L., R.D. Pieper, and C.H. Herbel. 1995. Range management (sec. ed.). Prentice-Hall, Inc., New Jersey. 526pp.

Hopper, R.M. 1972. Waterfowl use in relation to size and cost of potholes. J. Wildl. Manage. 36:459-468.

Jenkins, S.H., and B.D. Eshelman. 1984. Mammalian species (*Spermophilus beldingi*). Amer. Soc. Mammologists Species Account No. 221.

Kantrud, H.A. 1986. Effects of vegetation manipulation on breeding waterfowl on prairie wetlands - a literature review. U.S. Fish and Wildl. Serv., Wildl. Tech. Rep. 3. 15pp.

Kantrud, H.A. 1990. Effects of vegetation manipulation on breeding waterfowl in prairie wetlands--a literature review. pp. 93-123 *In* Severson, K.E., tech. ed. U.S. For. Serv. Gen. Tech. Rep. RM-194, Fort Collins, CO 123pp.

Kauffman, J.B., W.C. Krueger and M. Vavra. 1982. Impacts of a late season grazing scheme on nongame wildlife in a Wallowa mountain riparian ecosystem. *In* Peek, J.M., and P.O. Dalke, eds. Wildlife-livestock relationships symposium: Proc. 10. Univ. of Idaho, Moscow, ID. 614pp.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implication...a review. J. Range Manage 37:430-437.

Kerley, L. L., G. A Ekechukwu, and R. J. Hallock. 1993. Estimated historical conditions in the lower Carson River wetlands. Pages 7-20 *in* Hallock, R. J. and L. L. Hallock (eds.). Detailed study of irrigation drainage in and near wildlife management areas, west-central Nevada, 1987-90; Part B. Effect on biota in Stillwater and Fernley wildlife management areas and other nearby wetlands. U.S. Geological Survey, Water-Resources Investigations Report 92-4024B, Carson City, Nevada. 84pp.

Kie, J.G., and E.R. Loft. 1990. Using livestock to manage wildlife habitat: some examples from California annual grassland and wet meadow communities. pp. 7-24 *In* Severson, K.E., tech. ed. U.S. For. Serv. Gen. Tech. Rep. RM-194, Fort Collins, CO 123pp.

Kie, J.G., C.J. Evans, E.P. Loft, and J.W. Menke. 1991. Forage behavior of mule deer: The influence of cattle grazing. J. Wildl. Manage 55:665-674.

Kie, J.G., V.C. Bleich, A.L. Medina, J.D. Yoakum, and J.W. Thomas. 1994. Managing rangelands for wildlife. Pgs. 663-688 *in* T.A. Bookout (ed.). Research and management techniques for wildlife and habitats. The Wildl. Soc., Washington, D.C. 740pp.

Kindschy, R.R., C. Sundstrom, and J.D. Yoakum. 1982. Pronghorns. *In* Thomas, J.W., and C. Maser, tech. eds. Wildlife habitats in managed rangelands-the Great Basin of southeastern Oregon. U.S. For. Serv. Gen. Tech. Rep. PNW-145, Portland, OR. 18pp.

Kindschy, R.R. 1987. Riparian community ecological improvement with livestock use. Lecture series paper, Spokane, WA; Burns, OR; Lakeview, OR; Prineville, OR; Vale, OR; and McDermitt, NV.

Kirby, R.E., J.K. Ringelman, D.R. Anderson, and R.S. Sojda. 1992. Grazing on national wildlife refuges: Do the needs outweigh the problems? Presented at 57th North Am. Wildl. Nat. Res. Conf., Session 8, Charlotte, NC. 35pp.

Kirsch, L.M. 1969. Waterfowl production in relation to grazing. J. Wildl. Manage. 33:821-828.

Kirsch, L.M., H.F. Duebbert, and A.D. Kruse. 1978. Grazing and haying effects on habitats of upland nesting birds. pp. 486-497 *In* Trans. 43rd North American Wildl. and Natural Resources Conf. Wildl. Manage. Inst., Washington, D.C.

Klebenow, D.A. and R.J. Oakleaf. 1984. Historical avifauna changes in the riparian zone of the Truckee River, Nevada. Pages 203-209 *in* R.E. Warner and K.M. Hendrix (eds.). California riparian systems. Univ. of Calif. Press, Berkley, CA.

Kleinfelder, D. S. Swanson, G. Norris, and W. Clary. 1992. Unconfined compressive strength of some streambank soils with herbaceous roots. Soil Sci. Soc. Am. J. 56:1920-1925.

Knopf, F.L. 1996. Perspectives on grazing nongame bird habitat. Pgs. 51-58 *in* Krausman, P.R. (ed.). Rangeland wildlife. Soc. for Range Manage., Denver, CO. 440pp.

Knopf, F.L. and R.W. Cannon. 1982. Structural resilience of a willow community to changes in grazing practices. Pgs. 198-209 *in* Wildlife-livestock grazing relationships symposium. Proc. 10, Univ. of Idaho, Moscow.

Knopf, F.L., J.A. Sedgwick, and R.W. Cannon. 1988. Guild structure of a riparian avifauna relative to seasonal cattle grazing. J. Wildl. Manage. 52:280-290.

Koerth, B.H., W.M. Webb, F.C. Bryant, and F.S. Guthery. 1983. Cattle trampling of simulated ground nests under short duration and continuous grazing. J. Range Manage. 36:385-386.

Kovalchik, B.L. 1987. Riparian zone associations: Deschutes, Ochoco, Fremont, and Winema National Forests. U.S. For. Serv. Pacific Northwest Region. R6 ECOL TP-279-87, Portland, OR 171pp.

Kovalchik, B.L., and W. Elmore. 1992. Effects of cattle grazing systems on willow-dominated plant associations in central Oregon. pp. 111-119 *In* Clary, W.P., E.D. McArthur, D. Bedunah, and C.L. Wambolt, comps. Proc.--symposium on the ecology and management of riparian shrub communities. U.S. For. Serv. Gen. Tech. Rep. INT-289, Ogden, UT. 216pp.

Lacey, J.R. 1987. The influence of livestock grazing on weed establishment and spread. Proc. Mont. Acad. Sci. 47:131-146.

Laycock, W.A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. J. Range Manage 20:206-214.

Laycock, W.A. 1991. Stable states and thresholds of range condition on North American rangelands: A viewpoint. J. Range Manage. 44:427-433.

Leonard, S.G., G.J. Staidl, K.A. Gebhardt, and D.E. Prichard. 1992. Viewpoint: range site/ecological site information requirements for classification of riverine riparian ecosystems. J. Range Manage. 45:431-435.

Longland, W. S. 1992. Seed use by desert granivores. Pages 233-237 *in* Symposium on ecology, management, and research of Intermountain Annual Rangelands, Boise, Idaho.

Luken, J.O. 1990. Directing ecological succession. Chapman and Hall, NY. 251pp.

Mack, R.N., and J.N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. Amer. Nat. 119:757-772.

Marshall, D. 1951. Grazing Section of the Master Economic Use Plan, Stillwater Wildlife Management Area. Unpubl. report, U.S. Fish and Wildlife Service, Stillwater Nat. Wildl. Ref. office, Fallon, NV. 38pp.

Marshall, D.B. 1952. Habitat types of the Stillwater Marsh and their value to nesting ducks with reference to future management. Unpubl. report, U.S. Fish and Wildlife Service, Stillwater Nat. Wildl. Ref. office, Fallon, NV. 29pp.

Maser, C., J.W. Thomas, and R.G. Anderson. 1984a. The relationship of terrestrial vertebrates to plant communities, part 1, text. *In* Wildlife habitats in managed rangelands--the Great Basin of southeastern Oregon. U.S. For. Serv. Gen. Tech. Rep. PNW-172. Portland, OR. 25pp.

Maser, C., J.W. Thomas, and R.G. Anderson. 1984b. The relationship of terrestrial vertebrates to plant communities, part 2, appendices. *In* Wildlife habitats in managed rangelands--the Great Basin of southeastern Oregon. U.S. For. Serv. Gen. Tech. Rep. PNW-172, Portland, OR. 237pp.

Masters, L., S. Swanson, and W. Burkhardt. 1996. Riparian grazing management that worked, II. rotation with and without rest and riparian pastures. Rangelands 18(5):196-200.

McCluskey, D.C., J. Brown, D. Bornholdt, D.A. Duff, and A.H. Winward. 1983. Willow planting for riparian habitat improvement. U.S. Bur. Land Manage. Tech. Note 363 (BLM-YA-PT-83-007-4350), Denver, CO. 21pp.

Medin, D.E., and W.P. Clary. 1989. Small mammal populations in a grazed and ungrazed riparian habitat in Nevada. U.S. For. Serv. Res. Paper INT-143. Ogden, UT. 6pp.

Medin, D.E., and W.P. Clary. 1990. Bird and small mammal populations in a grazed and ungrazed riparian habitat in Idaho. U.S. For. Serv. Res. Paper INT-425, Ogden, UT. 4pp.

Meyers, T. J. and S. Swanson. 1995. Impact of deferred rotation grazing on stream characteristics in Central Nevada: a case study. N. Amer. J. Fisheries Manage. 15:428-439.

Miller, R.F., T.J. Svejar, and N.E. West. 1994. Implications of livestock grazing on the Intermountain sagebrush region: plant composition. Pgs. 101-146 *in* Vavra, M., W.A. Laycock, and R.D. Pieper. Ecological implications of livestock herbivory in the West. Soc. for Range Manage., Denver, CO. 297pp.

Minshall, G.W., S.E. Jensen, and W.S. Platts. 1989. The ecology of stream and riparian habitats of the Great Basin region: A community profile. U.S. Fish Wildl. Serv. Biol. Rep. 85(7.24). 142pp.

Monsen, S.B., and E.D. McArthur. 1985. Factors influencing establishment of seeded broadleaf herbs and shrubs following fire. pp. 112-124 *In* Sanders, K., and J. Durham. Rangeland fire effects: A symposium. U.S. Bur. Land Manage. Boise, ID. 124pp.

Morrison, R. B. 1964. Lake Lahontan: geology of southern Carson Desert, Nevada. Geol. Surv. Profess. Paper 401. U.S. Gov. Printing Off., Washington, D.C.

Mosconi, S.L., and R.L. Hutto. 1981. The effect of grazing on the land birds of a western Montana riparian habitat. *In* L. Nelson and J. Peek, eds. Proc. of the wildl.-livestock relationships symposium. Univ. of Idaho, Moscow.

Myers, T.J. and S. Swanson. 1991. Aquatic habitat condition index, stream type, and livestock bank damage in northern Nevada. Water Res. Bull. 27:667-677.

Myers, T.J. and S. Swanson. 1995. Impact of deferred rotation grazing on stream characteristics in central Nevada: a case study. North Am. J. Fish. Manage. 15:428-439.

Nevada Chapter of The Wildlife Society. 1995. Wildlife/livestock relations on rangelands in the Great Basin: a position statement by the Nevada Chapter-The Wildlife Society. 10pp.

Noss, R.F. 1983. A regional landscape approach to maintain diversity. Bioscience 33:700-705.

Noss, R. F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conserv. Bio. 4:355-364.

Noss, R.F. and A.Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Island Press, Washington, D.C. 416pp.

Nowak, C. L., R. S. Nowak, R. J. Tausch, and P. E. Wigand. 1994. A 30,000 year record of vegetation dynamics at a semi-arid locale in the Great Basin. J. Veg. Sci. 5:579-590.

Parman, M. 1986. Cattle for weed control. Rangelands. 8:183.

Paveglio, F. and others. 1997. Stillwater NWR Complex habitat management workshop: recommendations, July 7 and 8, 1997. Refuge files, Stillwater NWR Complex office, Fallon, Nevada.

Payne, N.F. 1992. Techniques for wildlife habitat management of wetlands. McGraw-Hill, Inc., St. Louis, MO. 549pp.

Peek, J.M. 1986. A review of wildlife management. Prentice-Hall, NJ. 486pp.

Pieper, R. D. 1994. Ecological implications of livestock grazing. Pages 177-211 *in* Vavra, M., W.A. Laycock, and R.D. Pieper. Ecological implications of livestock herbivory in the West. Soc. for Range Manage., Denver, CO. 297pp.

Platts, W.S. and R.L. Nelson. 1985. Streamside and upland vegetation use by cattle. Rangelands. 7:5-10.

Platts, W.S. 1989. Compatibility of livestock grazing strategies with fisheries. pp.103-110 *In* Gresswell, R.E., B.A. Barton, and J.L. Kershner, eds. Practical approaches to riparian resource management: An education workshop. U.S. Bur. Land Manage. BLM-MT-PT-89-001-4351, Billings, MT. 193pp.

Platts, W.S. 1990. Managing fisheries and wildlife on rangelands grazed by livestock: a guidance and reference document for biologists. Nevada Dept. of Wildlife, Reno, NV. 446pp.

Pond, F.W. 1961. Effect of three intensities of clipping on the density and production of meadow vegetation. J. Range Manage. 14:34-38.

Rouse, C.H. 1955. Range survey report: Stillwater Wildlife Management Area. Unpubl. report, U.S. Fish and Wildl. Serv. Stillwater Nat. Wildl. Ref. office, Fallon, NV. 30pp.

Provenza, F.D., and D.F. Balph. 1987. The development of dietary choice in livestock on rangelands and its implications for management. Pages 2356-2368 *in* D.R. Mertens, ed. Proc. Forage Selection and Intake by Grazing Rumin. Symp. Am. Soc. Anim. Sci., Champaign, IL.

Rule, M.I. 1989. The effects of cattle grazing on the distribution of mule deer on summer range in northeastern Nevada. M.S. Thesis. Univ. Nevada, Reno, NV. 78pp.

Ryder, R.A. 1980. Effects of grazing on bird habitats. Pgs. 51-66 *in* DeGraff, R.M. and N.G. Tilghman (compilers). Management of western forests and grasslands for nongame birds. U.S. Dep. of Agric., For. Serv. Gen. Tech. Rep. INT-86.

Samson, F.B. and F.L. Knopf. 1993. Managing biological diversity. Wildl. Soc. Bull. 21:509-514.

Sanders, K.D. 1992. Can annual rangelands be converted and maintained as perennial grasslands through grazing management? Symp.: Ecol., Manage., and Restoration of Intermountain Ann. Range. May 18-22, 1992. Boise, ID. 2pp.

Sanders, T.A. and W.D. Edge. 1998. Breeding bird community composition in relation to riparian vegetation structure in the western United States. J. Wildl. Manage. 62:461-473.

Schulz, T.T., and W.C. Leninger. 1991. Nongame wildlife communities in grazed and ungrazed montane riparian sites. Great Basin Nat. 5:286-292.

Sedivec, K.K, T.A. Messmer, W.T. Barker, K.F. Higgins, and D.R. Hertel. 1990. Nesting success of upland nesting waterfowl and sharp-tailed grouse in specialized grazing systems in Southcentral North Dakota. pp. 71-92 *In* Severson, K.E., tech. ed. U.S. For. Serv. Gen. Tech. Rep. RM-194, Fort Collins, CO 123pp.

Sedgewick, J.A., and F.L. Knopf. 1987. Breeding bird response to cattle grazing of a cottonwood bottomland. J. Wildl. Manage. 51:230-237.

Severson, K.E. 1990. Summary: Livestock grazing as a wildlife habitat management tool. pp. 3-6 *In* Severson, K.E., tech. coord. Can livestock be used as a tool to enhance wildlife habitat? U.S. For. Serv. Gen. Tech. Rep. RM-194, Fort Collins, CO. 123pp.

Sheeter, G.R., and E.W. Claire. 1981. Use of juniper trees to stabilize eroding streambanks on the South Fork John Day River. U.S. Bur. Land Manage. Tech. Note 6763. Portland, OR. 4pp.

Skovlin, J.M. 1984. Impacts of grazing on wetlands and riparian habitat: a review of our knowledge. Pgs. 1001-1103 *in* Nat. Res. Counc./Nat. Acad. Sci. (org.). Developing strategies for rangeland management. Westview Press, Boulder, CO.

Sneva, F.A., L.R. Rittenhouse, P.T. Tueller, and P. Reece. 1984. Changes in protected and grazed sagebrush-grass in eastern Oregon, 1937-1974. Oregon St. Univ. Agric. Exp. Stn. Bull. 663. Corvallis, OR. 11pp.

Spillett, J.J., J.B. Low, and D. Sill. 1967. Livestock fences--how they influence pronghorn antelope movements. Utah St. Univ. Agric. Exp. Stn. Bull. 470, Logan, UT. 79pp.

St. Clair, L.L., and J.R. Johansen. 1993. Introduction to the symposium on soil crust communities. Great Basin Nat. 53:1-4.

St. Clair, L.L., J.R. Johansen, and S.R. Rushforth. 1993. Lichens of soil crust communities in the intermountain area of the western United States. Great Basin Nat. 53:5-12.

Strassmann, B.I. 1987. Effects of cattle grazing and haying on wildlife conservation at National Wildlife Refuges in the United States. Envir. Manage. 11:35-44.

Stuth, J.W. 1991. Foraging Behavior. Pages 65-83 *in* R.K. Heitschmidt and J.W. Stuth, eds. Grazing Management: an ecological perspective. Timber Press, Portland, OR. 259pp.

Swanson, S. 1996. Simulated stream bank erosion of surface and subsurface samples from three meadow plant communities. Pages 100-107 *in* Subcommittee on Sedimentation Interagency Advisory Committee on Water Data (sponsor). Proceedings of the Sixth Federal Interagency Sedimentation Conference, Las Vegas, Nevada.

Taylor, D.M. 1986. Effects of cattle grazing on passerine birds nesting in riparian habitat. J. Range. Manage. 39:254-258.

Taylor, and C.D. Littlefield. 1986. Willow flycatcher and yellow warbler response to cattle grazing. Pop. Ecol. 40:1169-1173.

Thomas, J.W., tech. ed. 1979. Wildlife habitats in managed forests of the Blue Mountains of Oregon and Washington. U.S. For. Serv. Agric. Handbook 553, Washington, D.C. 512pp.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1979. Riparian zones. *In* Wildlife habitats in managed rangelands--The Great Basin of southeastern Oregon. U.S. For. Serv. Gen Teck. Rep. PNW-80. Portland, OR. 18pp.

Tisdale, E.W., and M. Hironaka. 1981. The sagebrush-grass region: a review of the ecological literature. Univ. of Idaho Range, For., and Wildl. Exp. Stn. Bull. 33. Moscow, ID. 31pp.

U.S. Bureau of Land Management (USBLM). 1991. Final environmental Impact statement: vegetation treatment on BLM lands in thirteen western states. U.S. Bur. Land Manage. BLM-WY-ES-91-022-4320. Cheyenne, WY.

USBLM. 1991b. Whitehorse butte biological assessment. Unpubl. rep., U.S. Bureau of Land Manage., Vale, OR. 25pp.

U.S. Fish and Wildlife Service (USFWS). 1982. National Wildlife Refuge System Refuge Manual. U.S. Dept. Interior, Fish Wildl. Serv., Washington, D.C.

USFWS. 1990. Blitzen Valley management plan: Malheur National Wildlife Refuge, Oregon. U.S. Fish Wildl. Serv., Malheur National Wildlife Refuge, Princeton, OR. 169pp.

USFWS. 1992. North American Waterfowl Management Plan: Concept Plan for the Preservation of Wetland Habitat of the Intermountain West. U.S. Fish and Wildl. Serv., Region 1, Portland, Oregon.

Vallentine, J.F., and A.R. Stevens. 1992. Use of livestock to control cheatgrass - A review. Symp.: Ecol., Manage., and Restoration of Intermountain Ann. Range. May 18-22, 1992. Boise, ID. 2pp.

Van Havereen, B.F., and W.L. Jackson. 1986. Concepts in stream riparian rehabilitation. North American Wildl. and Nat. Resources Conf. Trans. 51:280-289.

Wasser, C.H. 1982. Ecology and culture of selected species useful in revegetating disturbed lands in the West. U.S. Dept. of the Interior, Fish and Wildl. Serv. FWS/OBS-82/56. 347pp.

Whyte, R.J. and B.W. Cain. 1981. Wildlife habitat on grazed or ungrazed small pond shorelines in south Texas. J. Range Manage. 34:64-68.

Whyte, R.J., N.J. Sylvy, and B.W. Cain. 1981. Effects of cattle on duck food plants in southern Texas. J. Wildl. Manage. 45:512-515.

Winegar, H.H. 1977. Camp Creek channel fencing--plant, wildlife, soil, and water response. Rangeman's J. 4:10-12.

Winward, A.H. 1985. Fire in the sagebrush-grass ecosystem--the ecological setting. pp. 2-6 *In* Sanders, K., and J. Durham. Rangeland fire effects: A symposium. U.S. Bur. Land Manage. Boise, ID. 124pp.

Winward, A.H. 1991. A renewed commitment to management of sagebrush grasslands. pp. 2-7 *In* Miller, R.F., ed. Management in the sagebrush steppe. Oregon St. Univ., Agric. Exp. Stn. Special Rep. 880, Corvallis, OR. 48pp.

Wiseman, G.L. 1962. Economic use plan: Stillwater Wildlife Management Area. Unpubl. report, U.S. Fish and Wildl. Serv., Stillwater Nat. Wildl. Ref. office, Fallon, NV. 23pp.

Young, J. A. 1994. Historical perspectives and evolutionary perspectives on grazing of Western rangelands. Pages 1-12 *in* Vavra, M., W.A. Laycock, and R.D. Pieper. Ecological implications of livestock herbivory in the West. Soc. for Range Manage., Denver, CO. 297pp.

Young, J.A., R.A. Evans, and P.T. Tueller. 1976. Great Basin plant communities--pristine and grazed. pp. 187-215 *In* Halston, R., ed. Holocene environmental change in the Great Basin. Nevada Archeaology Society Res. Paper 3.

Young, R.P. 1986. Fire ecology and management in plant communities of Malheur National Wildlife Refuge, southeastern Oregon. Ph.D. Diss., Oregon. St. Univ., Corvallis, OR. 183pp.

Young, J. A., R. R. Blank, W. S. Longland, and D. E. Palmquist. 1994. Seeding Indian ricegrass in an arid environment in the Great Basin. J. Range Manage. 47:2-7